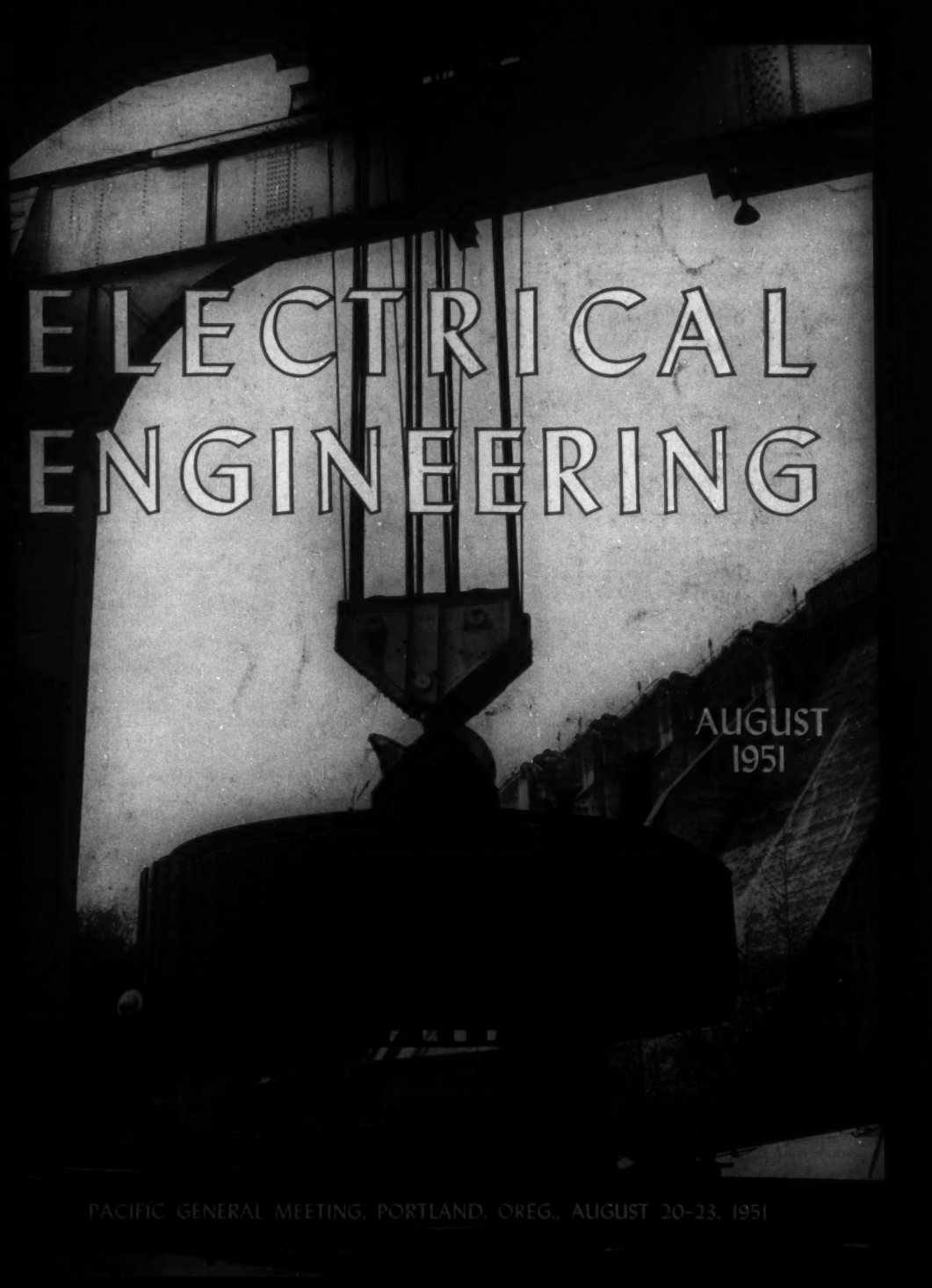
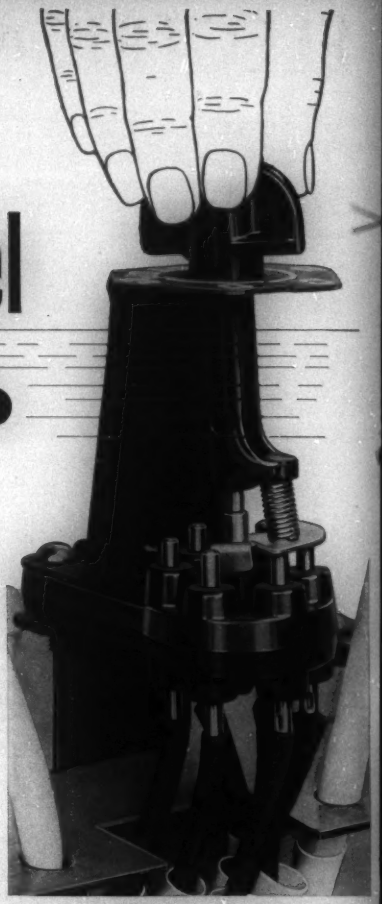


PACIFIC GENERAL MEETING, PORTLAND, OREG., AUGUST 20-23, 1951

TAP CHANGER Operated Above Oil Level

NOW STANDARD

ALLIS-CHALMERS
DISTRIBUTION TRANSFORMERS



THIS NEW tap changer has its operating handle and indicating dial plate extended *above the hot oil level* for convenience in changing taps. It's easy to operate, easy to read and requires no maintenance. Attractive and compact, the design is based on the sturdy construction features that have given Allis-Chalmers tap changers top performance for many years.

Bold white letters mark tap positions on a black vulcanized fiber dial plate. Cautioning area indicates the location of limiting stops.

As the molded plastic assembly is turned, the high pressure contact snaps into position with a wiping action. The contact shoe is V-shaped so that it makes a positive stop in a position bridging two studs.

You can get Allis-Chalmers *new* long handled internally operated tap changer in distribution transformers rated 100 kva and smaller single phase; 150 kva and smaller three phase. For more information contact your local Allis-Chalmers sales office or write Allis-Chalmers, Milwaukee 1, Wis.

A-3439

Leads are firmly crimped to tap changer studs for a lifetime connection.

ALLIS-CHALMERS A-C ALLIS-CHALMERS

ELECTRICAL ENGINEERING

Registered United States Patent Office

AUGUST
1951

The Cover: Lowering a 56,000-kva vertical waterwheel generator rotor into place at Merwin Dam. This is typical of the many private power company hydroelectric installations all interconnected throughout the Northwest power pool. Pacific Power and Light Company photograph

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VOL. 70 NO. 8

Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Headquarters
33 West 39th Street
New York 18, N. Y.

Founded 1884

Editorial Offices
500 Fifth Avenue
New York 18, N. Y.

F. O. McMILLAN, President
H. H. HENLINE, Secretary

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A MESSAGE TO AMERICAN INDUSTRY

"This is more than a shortage . . . this is an emergency.

Every pound of your scrap is needed, NOW !"

"THE STEEL INDUSTRY is currently operating at more than 100% of rated capacity—turning out well over 2 million tons of steel per week. This record high production—every ton of which is in urgent demand—cannot be kept up unless we get more scrap from every potential source. For without your scrap we cannot produce enough steel. Today, every ton of steel turned out requires a half a ton of scrap for its production. That's why scrap—more scrap—is so urgently needed, and needed right away.

"The fact we have to face today is that steel mills are operating on a hand-to-mouth basis as far as scrap is concerned. Some mills are working on only a two-day supply of scrap. We already have had to shut down steel-making furnaces for lack of scrap.

"That's why we are asking you to strain every effort to get more scrap out of your plants and yards and on its way to the mills . . . to search out the scrap that doesn't come to market in normal times. You'll find this "dormant" scrap in obsolete equipment, tools and machinery that you haven't used for years . . . overlooked in your storage sheds . . . or rusting away in a junk pile in some forgotten corner. It's there. Turn it in at once—*so we can turn out the steel you need.* We can't do it without your help."

President, United States Steel Corporation

USS

1-1182

UNITED STATES STEEL

HIGHLIGHTS.....

Some Objectives for 1951–52. Incoming President F. O. McMillan discusses some of the problems which face the Institute as it enters a new year. Those which are emphasized include: growth; students and student branches; unity of the engineering profession; and engineering manpower (*pages 657–59*).

Lamme Medal. The Lamme Medal for 1950 was awarded to Donald I. Bohn, Aluminum Company of America. The presentation speeches are printed in this issue. A. H. Kehoe gives the history of the medal, and Thomas D. Jolly the career of the medalist. Mr. Bohn discusses the problem of electric power for aluminum reduction plants (*pages 663–66*).

Board of Directors' Report. The 67th annual report of the AIEE Board of Directors is presented in full in this issue. Covering the fiscal year ending April 30, 1951, it contains a brief summary of Institute activities and statements of the financial status of the Institute (*pages 724–50*).

Research in a Defense Economy. It is necessary for industry and the government to recognize the importance of organized research if the United States is to maintain its high standard of living, to conduct its defense economy successfully, and to preserve its democratic way of life (*pages 660–62*).

Cadmium Sulphide Conductivity. The use of cadmium sulfide crystals in an instrument for X-ray inspection of canned goods, fuse trains, and other substances is described this month. Formerly, this type of equipment used the average value of conduction current, but the long time needed for stable output after radiation made that method unsatisfactory. The new design utilizes the rate of change of crystal conduction current when subjected to pulsing X radiation (*pages 667–71*).

Medium-Haul Carrier System. Emphasis on cost reduction has made possible a new telephone carrier system that is economical for exchange circuits in the range from 15 to 200 miles. Many novel features, including a low-cost "compandor," keep performance up to high standards (*pages 692–97*).

New Membership Requirements

As announced at the Annual Meeting in Toronto on June 25, the proposed amendments to the Constitution have been approved by ballot of the membership and, in accordance with Section 69 of the Constitution, the new provisions go into effect 30 days after the Annual Meeting—or July 25, 1951.

Any applications for membership or change of grade made after July 25 must be made on new forms. It is necessary therefore that the forms previously in use be discarded and new ones obtained from AIEE headquarters or Section Membership or Transfer Committees. Any applications received on the now obsolete forms will be returned to the applicant along with information regarding the new requirements and a new form.

Dynamic Strain Measurement. While primarily the mechanical engineer's problem, the electrical engineer will find interesting this discussion of electrical methods for measuring the dynamic strain in structural members (*pages 675–78*).

Transformer Protection. A carrier-current frequency-shift system for remote operation of circuit breakers in the event of transformer fault is described. A high degree of reliability and fast action are two important features of the system (*pages 678–87*).

A High-Current Thyratron. A recently developed thyratron, filled with inert gas, has the grid-anode structure arranged to permit operation at a high commutation factor with no gas clean-up. It has a peak current rating of 150 amperes and an average current rating of 12.5 amperes (*pages 698–99*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Jul '50, p 30A	Winter General North Eastern District Great Lakes District Summer and Pacific General
Nov '50, p 44A	Middle Eastern District Fall General
Mar '51, p 35A	Winter General
Jul '51, p 23A	Southern District North Eastern District Great Lakes District Summer General

Cyclic Light Flicker. The annoying effects of light flicker due to voltage fluctuations caused by such devices as welding apparatus have been studied thoroughly. The results of the study indicate that the duration of voltage dips as well as their frequency is an important factor in perception of flicker in lights (*pages 685–89*).

A Teleprinter Signal Bias Meter. A meter has been designed to monitor and correct distortion of a teleprinter signal caused when the response of a relaying device is not symmetrical. The same meter can be used to determine if separate teleprinter lines radiating from a hub are transmitting unbiased signals into the network (*pages 703–05*).

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Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925.

August 1951, Vol. 70, No. 8. Number of copies of this issue 51,600

To Design Engineers with Special Capacitor Problems . . .

HERE ARE TWO DIFFERENT CENTRALAB CERAMIC CAPACITORS WITH UNUSUAL HIGH VOLTAGE, HIGH ACCURACY CHARACTERISTICS

FOR HIGH VOLTAGE . . .

Centralab's Type 850 series high voltage (7500 to 20,000 Volts D. C.) ceramic capacitors are designed for transmitters, induction heaters, electronic welding equipment, x-ray, diathermy or other similar high voltage, high frequency circuits. They have extremely low power factor and stable retrace characteristics. Small physical dimensions make them well suited to high-powered portable or mobile transmitters and similar equipment where space and weight are at a premium. Long leakage paths and rugged mechanical construction are afforded by Centralab's unique "double cup" design. Centralab's High Voltage ceramic capacitors meet specifications of JAN C-20A for humidity test.

FOR HIGH ACCURACY . . .

Centralab's type 950 high accuracy ceramic capacitors (500 to 2,400 mmf) represent the ultimate in precision for exacting electronic applications. Extremely rigid capacitance and temperature coefficient tolerances make them well suited to oscillator circuits of primary and secondary frequency standards, frequency meters and similar precision electronic equipment. Low inductance and low power factor permit operation at virtually all radio frequencies. Each capacitor is hermetically sealed in a silver plated brass, cup-shaped shell which shields it against stray capacitance effects. Shell is connected at ground potential through the threaded stud which holds it to the chassis.

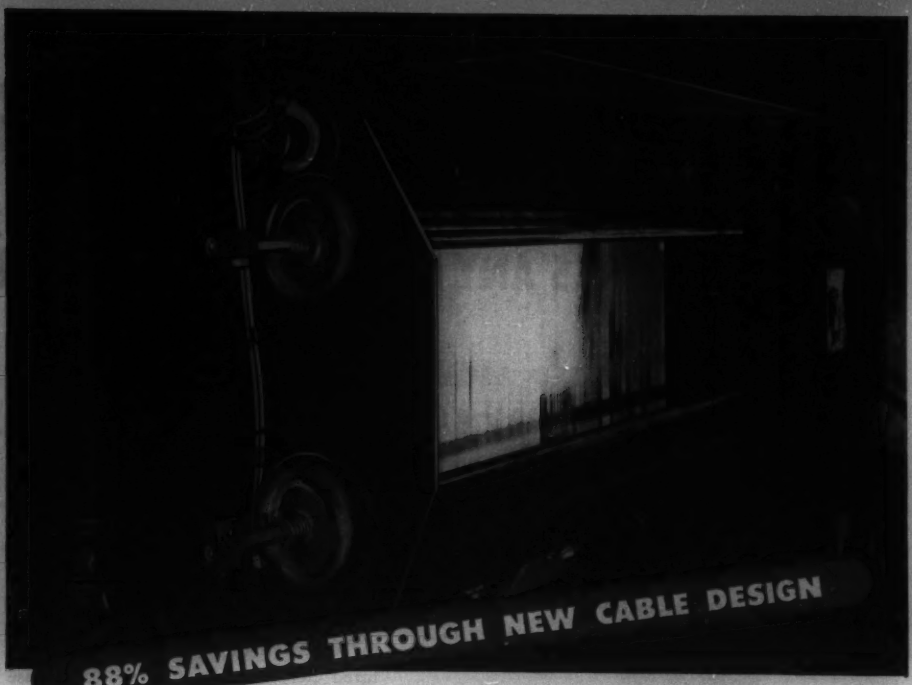
When it comes to high voltage or high accuracy capacitors — you can't beat ceramics — Centralab ceramics — the most permanent type capacitors. Both Type 850 series (high-voltage) and Type 950 (high accuracy) have proven life tests of 1000 hours at + 85°C at voltages well in excess of rating in accord with proposed RTMA Standards. The ceramic dielectric used is Centralab's exclusive Ceramic X. Terminals are silver plated brass or copper. Power factors are .1% maximum measured at 1 megacycle. For complete information on Type 850 Series (high voltage) and Type 950 (high accuracy) capacitors — write for bulletins listed. Special capacitors and engineering assistance available.

You can get complete technical data and specifications on Centralab's Type 850 Series (High Voltage) and Type 950 (High Accuracy) capacitors. Write for Bulletin 42-102 or Bulletin 41-123 respectively.

Centralab

Division of GLOBE-UNION Inc.

932 E. Keefe Ave. • Milwaukee 1, Wisconsin



How Okonite-engineered cables save money for the McCall Corporation

Engineers of the McCall Corporation, Dayton, Ohio, sought a means of reducing their insulated cable replacements on six printing presses. The ordinary cables used for supplying the gas ignition apparatus failed quickly because of temperatures ranging from 350 to 450°F. Monthly replacements of the standard rubber-insulated automotive ignition cable previously used gave rise to the following costs:

BEFORE

Cost of cable per year	**$650.00**
Labor in replacement	**900.00**
Yearly cost: materials and labor	**$1550.00**

In 1948, at the suggestion of an Okonite engineer, McCall installed Okonite's heat-resistant Okotherm cable. Since then, no replacements have been made under conditions of normal usage. Although the Okotherm cable was several times as expensive, experience has already shown that annual costs have been reduced to a mere fraction of the previous cost, as follows:

NOW

Cost of cable per year	**$142.00**
Labor on installation	**37.50**
Total yearly cost using Okotherm	**$179.50**

...a saving of 88.5%

• • •

Stories like this are not unusual in the file of actual case histories at Okonite. For the broad research and design and manufacturing skills which have developed such long-lived, trouble-free cables for normal use, have also developed many types for highly specialized applications.

These facilities are available to *you*, to help solve any difficult cable problems arising in *your* operation. Don't hesitate to call in your nearest Okonite representative, or write The Okonite Company, Passaic, N. J.

THE BEST CABLE IS YOUR BEST POLICY

insulated wires and cables

9188

NEW LOW COST

BREAKS ANY CHARGING CURRENT AND

THE TIME-TESTED ALDUTI INTERRUPTER SWITCH AT CONVENTIONAL AIR BREAK SWITCH PRICES

Since 1939 the reliability of the solid-material confined-arc extinction method of high voltage circuit interruption illustrated below has been proved under actual service conditions in thousands of installations for switching full rated load currents, line- and cable-charging currents, and magnetizing currents.

This circuit interrupting principle is now available in group-operated arrangements for pole-top switching at prices that compare with horn gap switches.

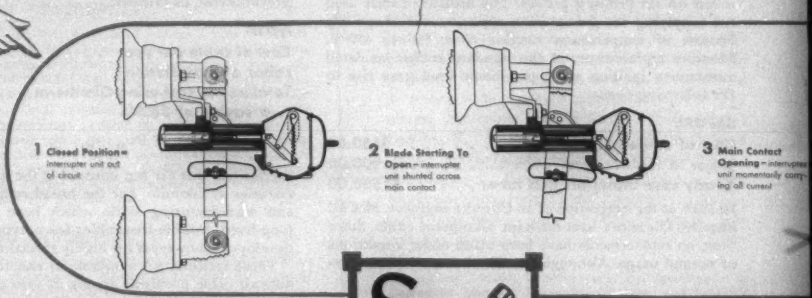
Because there is no external arc, this interrupter switch can be inverted, or mounted vertically, for simple installation and maintenance.

Further, because there is no external arc, the cost-saving side-opening design pictured here actually requires less phase spacing than a horn gap switch.

• • •

Full details are available from your local S&C representative, or the factory.

HERE'S HOW THE ALDUTI INTERRUPTER UNIT OPERATES TO PROVIDE CONFINED-ARC SWITCHING

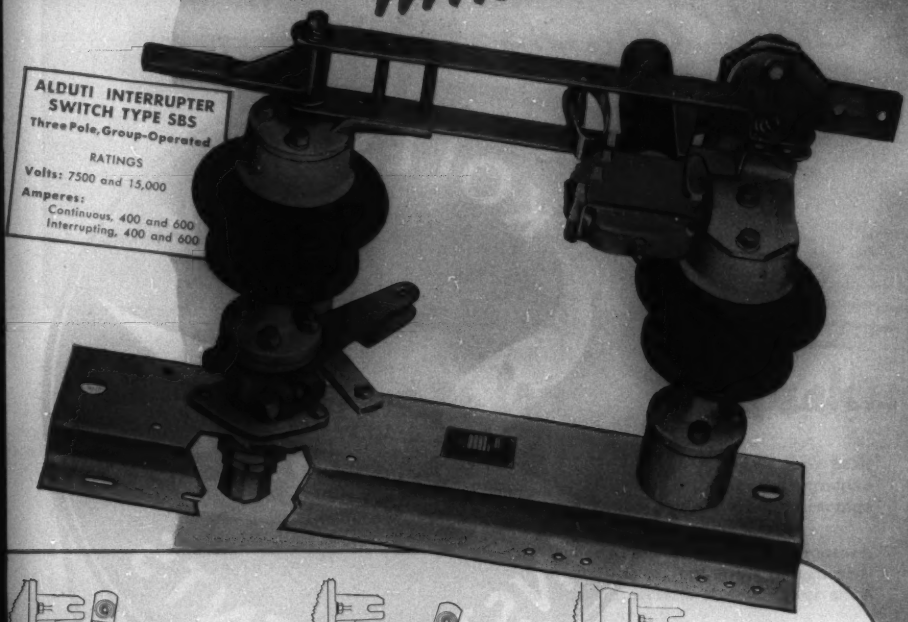

1 Closed Position – interrupter unit out of circuit
2 Blade Starting To Open – interrupter unit shunted across main contact
3 Main Contact Opening – interrupter unit momentarily carrying all current

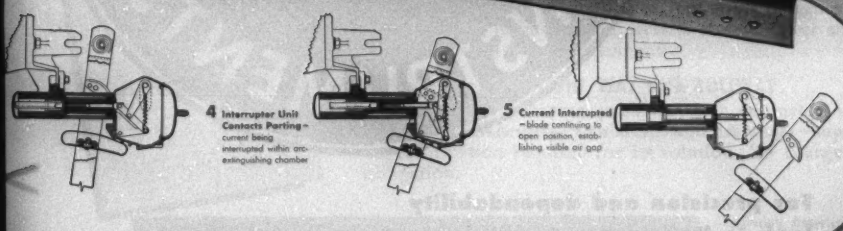
S&C ELECTRIC

Formerly SCHWEITZER & CONRAD, INC.

POLE TOP SWITCH

FULL LOAD CURRENT *WITHOUT ARCING!*




4 Interrupter Unit Contacts Parting – current being interrupted within arc-extinguishing chamber
5 Current Interrupted – blade continuing to open position, establishing visible air gap

COMPANY

4427 Ravenswood Avenue
Chicago 40, Illinois, U. S. A.

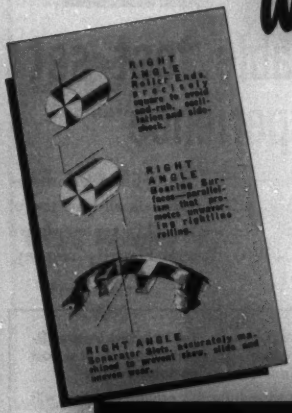
In Canada, Powerlite Devices, Limited, Toronto

For precision and dependability look to Kollsman

KOLLSMAN INSTRUMENT CORPORATION

Elmhurst, New York • Glendale, California

When the load hits its peak...



. . . Rollway Bearings are still performing at *their* peak efficiency! There's no skew—no end-rub—no destructive side shock—therefore, no power loss. Rollway Bearings continue to *roll right* because they're *made right.*

On pinion and commutator ends of traction motors, the inbuilt trueness of Rollway's right angle design provides smooth, uninterrupted service. Result: fewer shutdowns for service or replacement.

Roll the RIGHT WAY with ROLLWAY

Send us your bearing problem. Our engineers will gladly make necessary calculations and drawings—supply the information required for its solution. No charge or obligation.

ROLLWAY BEARINGS

Complete Line of Radial and Thrust Cylindrical Roller Bearings

Rollway Bearing Co., Inc.
Syracuse, N. Y.

SALES OFFICES

Philadelphia · Boston · Pittsburgh
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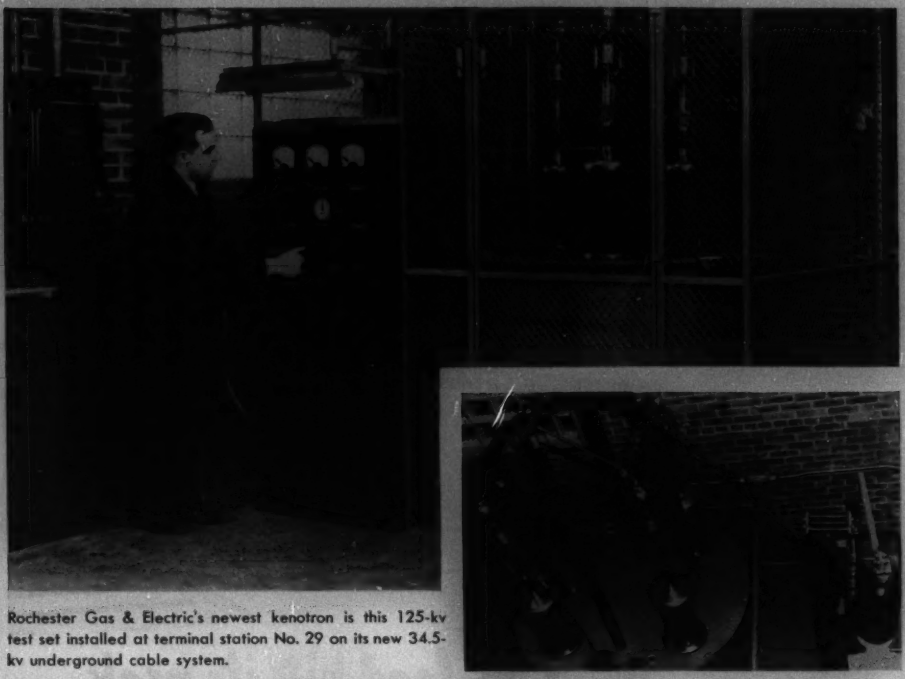
Houston · Los Angeles



Rochester Gas & Electric's newest kenotron is this 125-kv test set installed at terminal station No. 29 on its new 34.5-kv underground cable system.

R. G. & E. purchases 125-kv cable test set as a result of earlier experience

For almost 25 years, Rochester Gas & Electric Corp. of Rochester, N. Y., has used a 50/100-kv G-E kenotron test set on its 11-kv underground cable system, and has recently purchased an additional kenotron for testing cable on its new 34.5-kv system.

General Electric d-c cable test sets improve continuity of service by detecting cable faults before they occur. Thus, emergency calls are avoided and repair crew operations can be scheduled when loads are off peak. Also, repair materials can be purchased far enough in advance to avoid being "caught short."

D-c cable testing causes no deterioration of cable insulation. For details on the many other advantages of d-c testing with G-E kenotron sets and for useful application data, call your nearest G.E. representative or write to Section 401-91, General Electric Company, Schenectady 5, N. Y.

Cable testing equipment can be included in specifications for a complete cable installation—at a cost that is almost insignificant in the total outlay.

It will pay you to include this equipment. You will have it when you need it—beginning with the acceptance tests, and continuing through periodic testing during the entire life of the system.

401-91

GENERAL ELECTRIC

Announcing

THE NEW 50 AMP

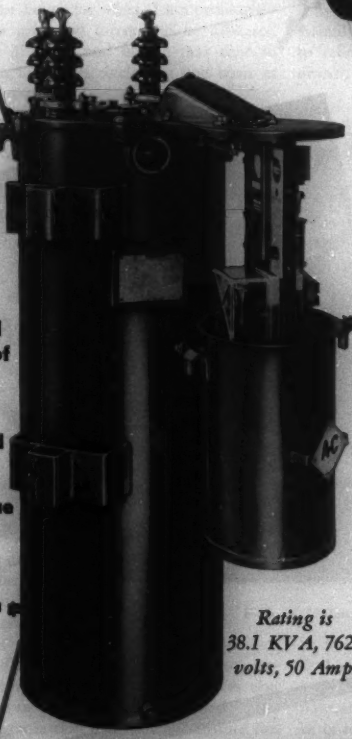
ALLIS-CHALMERS 5/8% STEP VOLTAGE REGULATOR

Improves Service —Cuts Complaints

Provides Full 20% Range of Regulation

± 1 Volt Band

Raises Revenue by Increasing KWH Consumption



Rating is 38.1 KVA, 7620 volts, 50 Amp.

NOW YOU CAN take advantage of the features of the JFR regulator in a new rating. The new 50 ampere regulator gives you all the quality features of Allis-Chalmers ⅝% step regulators with a low price tag that makes regulation more economical than ever before. Regardless of load changes or voltage difficulties, with this new regulator you can keep voltage constant at any given point on a line.

The new 50 amp JFR regulator is fully automatic. It regulates line voltage through a range of 20% in 32 small ⅝% steps, and holds ± 1 volt band. Rating is 38.1 kva, 7620 volts, 50 amps for operation at 7960, 7200, 6900, 5000, 4330 and 2500 volts.

Simple Adjustment

Maintenance and adjustment are easy. The unit type control is grouped on a single control panel where it is readily accessible for adjustment or inspection. You need to make only two knob settings. Voltage level and voltage band can be set in less than 60 seconds.

Jump-Proof Mounting Brackets

The jump-proof mounting brackets on this new 50 amp JFR regulator are the same as used on distribution transformers. A heavy driving motor operates under oil for tap changing. There are no commutators, slip rings, brushes, no centrifugal switch.

Today, consult your Allis-Chalmers sales office for complete details on how the new 50 amp JFR regulator can serve you. Or write: Allis-Chalmers, Milwaukee 1, Wisconsin. A-3392

ALLIS-CHALMERS

Originators of ⅝% Step Regulation

A page from the note-book of Sylvania Research

Sylvania engineering aids the development of a Subminiature Decade Counter

The apparatus shown at right is a test board, engineered by Sylvania for the development of a Subminiature Decade Counter.

Of special interest are the tiny Sylvania Subminiature Trigger Tubes which fire with a small negative pulse to the grid. No other electronic tubes or crystal diodes are required in the counter circuit.

This test board allows for independent variation of all the condensers and resistors in the complete decade circuit. Thus the circuit can be optimized to gain maximum counting speed for each new improvement in tube design. As a result, both tube and circuit development progress simultaneously.

This counter test board is a typical example of the ingenuity of Sylvania engineers in exploring new techniques . . . new approaches to the development of new and more efficient products.

Engineer shown peaking up circuit to gain maximum counting speed from newly designed Sylvania (T-1) Trigger Tube.

SYLVANIA ELECTRIC

ELECTRONIC DEVICES; RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC TEST EQUIPMENT; FLUORESCENT TUBES, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; PHOTOLAMPS; TELEVISION SETS

Some Objectives for 1951-52

F. O. McMILLAN
PRESIDENT AIEE

The incoming President solicits the co-operation of the members in helping him fulfill his outlined objectives designed to promote the growth and progress of the Institute to new heights of service and prestige.

SINCE the American Institute of Electrical Engineers was founded in 1884 it has conferred the presidency on 63 of its members. These presidents have reflected honor on the Institute and on the engineering profession. To be selected to assume the leadership of this great engineering society that has been led by such an illustrious group of engineers is an honor for which I am profoundly grateful. It has been my good fortune to be affiliated with the Institute for 37 years and during that time to have served in various capacities, including one term as Vice-President, and I am now completing three years as a Director. These associations have been among the most enjoyable and satisfying in my life. The year ahead will be a busy one filled with many duties, responsibilities, obligations, and decisions in all of which I solicit your co-operation and help. I pledge you my best effort, and working together we shall continue the Institute's upward progress to new heights of service and prestige.

F. O. McMillan

Presidents of the AIEE are nominated and elected to office on faith based upon past performance. They make no campaign commitments or promises to be kept or broken. It is therefore fitting that you should have some statement from me at this time setting forth some of the objectives toward which, in addition to our normal activities, we should, in my opinion, direct our efforts. We shall not all be in agreement regarding the importance of these objectives and it is not necessary or even desirable that we should. The strength of a great organization such as our Institute lies in the fact that there are honest differences of viewpoint and opinion, but we can and do reconcile these differences and work out organization problems, procedures, and programs that are in the common interest.

Full text of the address presented in acceptance of the President's badge at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951.

F. O. McMillan is Head of the Department of Electrical Engineering, Oregon State College, Corvallis, Oreg.

PROBLEMS OF GROWTH

THE FIRST OBJECTIVE of any well-conducted organization should be to keep its own house in order. Therefore it is my proposal that we work hard to integrate and assimilate the organization changes that have been made to relieve the pressures created by the extremely rapid growth in membership and committee activities during and following World War II. The membership doubled in the ten year period between 1940–50. Some of the organization changes made may not be satisfactory or desirable. In such instances adjustment should be made, not hastily, but as experience indicates the way. Further reorganization may be necessary to relieve the burden on some committees, committee chairmen, and officers. The organization required to meet the needs of the Institute should be a subject of constant study and investigation in order that growth and development may not be impaired by an inadequate or unwieldy administrative structure.

Over the years the reorganization of the Institute to meet changing conditions and problems related to growth has demanded changes in the Constitution and particularly in the By-Laws. Since these changes have been made piecemeal at irregular intervals it appears that the time has now arrived when a thorough revision and rewriting is in order, not necessarily to change existing provisions, but to clarify and systematize their presentation.

The Publication Committee has been working hard and effectively with the problem of obtaining the best solution of the publication requirements of the Institute within the financial limitations now imposed. Notwithstanding this effort, there still remain, and there probably always will

be, some publication problems. Of the current problems probably the most important, and one which demands a decision, is what to do about the 270 per cent increase in unpublished papers in the 7-year period from 1944 to 1951 while the number of published papers remained essentially constant, showing only a three per cent increase in the same period. The unpublished papers are in three classifications; namely, conference papers, district papers, and advance-copies-only (ACO) papers. In 1950 conference papers constituted 66 per cent, district papers 24 per cent, and ACO papers 10 per cent of the unpublished papers. It is apparent therefore that the conference papers constitute the bulk of the problem.

The conference and the conference-type paper, as I understand them, were instituted for the purpose of discussing, informally, certain subjects and problems where written records did not appear necessary or desirable. It is believed that they have gone far beyond the original purpose and that many of the papers now being presented have at least transient value and some of them permanent value. However, since the conference papers are not published except in rare instances, the information contained in them is available only to the few members who are able to attend the conference. The exceptions to this situation are, when the appropriate technical committee reviews a paper after presentation and recommends it for the *Transactions*, or either the author or his employer has the paper reproduced and is prepared to mail it to those interested upon request. This condition needs to be rectified but it probably cannot be changed materially until additional funds are available for publications.

STUDENTS AND STUDENT BRANCHES

The AIEE was the first engineering society to establish Student Branches and Student Memberships almost half a century ago. The purpose at that time was to interest young engineers in, and train them for, professional work in what was then a very young and rapidly growing electrical industry. Today we have the same purpose and for exactly the same reasons. Recent surveys show that Student Branches are attracting only about 33 per cent of the electrical engineering students to Student Membership. These surveys also show that in general the Branches in small institutions are doing a better job of attracting members than those in large institutions. We should have more Branches striving for 100 per cent membership and every Branch carrying on an active and constructive program.

The Board of Directors has agreed to plow back into student activities the increased revenue from the higher student dues of $5.00 per year which became effective May 1, 1951. The only requirement to gain this added support for student activities is the submission of an acceptable program to the Board. Such a program is being planned by the Committee on Student Branches and should be put in effect during the next administrative year.

UNITY OF THE ENGINEERING PROFESSION

Most, if not all, engineers agree that it would be a great asset to the engineering profession if it could act as a unit, particularly within national boundaries on matters of interest and importance to all engineers regardless of their specialized field of technical interest. There are, however, wide differences of opinion as to how this unity of the engineering profession can best be attained. The fact that there is almost universal acceptance of the need for unity of the profession constitutes the greatest justification for employing our best efforts to achieve that unity.

Upon the recommendation of its Committee on Unity, the Engineers Joint Council (EJC) invited representatives of 16 major engineering societies to form an Exploratory Group for the Study of the Unity of the Engineering Profession. One society has since resigned, leaving 15 societies in the group. The Exploratory Group at its meeting of December 16, 1950, adopted a report presenting four possible plans for organization for increased unity of the engineering profession which were designated as plans A, B, C, and D. Plan A proposes expansion of EJC. Plan B is similar to Plan A with the addition of provision for membership of individual engineers of high qualifications, in addition to the membership of engineering societies. Plan C proposes an amalgamation of EJC and the National Society of Professional Engineers (NSPE) as a basis for the unity of organization. Plan D proposes the development of the NSPE for this purpose. These plans were transmitted to the Sections and Subsections on January 2, 1951, for comments and an expression of preference but not for final decision.

In recent years many unity plans have been proposed, considered, and voted upon; so many, in fact, that I fear there has been much confusion, some frustration, and in some instances a sense of hopelessness regarding our ability to ever resolve this problem. However, since the basic idea is generally accepted as being sound fundamentally we should not give up but keep on working for a satisfactory solution.

Perhaps we are too impatient and expect to accomplish too much in too short a time. Probably the largest co-operative enterprise previously undertaken by the engineering societies was the construction of the Engineering Societies Building. When Professor Charles F. Scott was President of the Institute (1902–03) he proposed a large building to house the four founder societies. He was told that the societies simply would not pull together; "theoretically it is all right, but practically it won't work." Professor Scott said that if the plan was all right theoretically it was good enough for him to talk about and he went to work. On February 14, 1903, Andrew Carnegie gave the engineering societies $1,000,000 more or less according to need. Even at that early date Mr. Carnegie recognized the importance of co-operation among the engineering societies and made the stipulation that the grant was contingent upon all four societies accepting the gift and participating in the use of the building. Professor Scott and others interested in the building enterprise worked for a year trying to arrive at a basis for co-operation. There was dissension and at the end of a year one society voted not to join in accepting the gift. Three societies did agree upon a basis for co-operation and to accept the gift. Notwithstanding his original stipulation Mr. Carnegie

increased the gift to $1,500,000 and agreed to proceed with the construction of the Engineering Societies Building, provided the way would be left open for the fourth society to participate if they decided to do so at a later date. The fourth society did not join the other three in the use of the building until 1917, 14 years after the conception of the idea and ten years after the building was completed in 1907. It is apparent that sometimes it requires a long time to work out really worth-while and important projects; therefore, we should not despair of achieving unity of the engineering profession.

ENGINEERING MANPOWER

We stockpile critical raw materials, copper, nickel, tin, zinc, rubber, and so forth, but our most important and critical resource, manpower, skilled in engineering and science, we use with abandon and almost without regard for aptitude and special training. This practice must stop if we are to survive because there are those in the world who constantly strive to devise ways and means of destroying us. We must seek out the boys and girls with the native ability to develop in the fields of engineering and science and see that they are trained.

The Engineering Manpower Commission of the EJC is doing a valiant job against great odds. These odds are created, for the most part, by the fear and timidity of politicians which restrains them from taking the action necessary to conserve manpower in the critical categories. Therefore, we must give the Manpower Commission every encouragement and assistance in their effort to see that engineering graduates and all engineers are placed in positions where they can make the greatest contribution to the general welfare.

There is a growing tendency in the field of secondary education which, in the opinion of many in the field of engineering education, is tending to dry up the potential supply of engineering students at the source. This trend is to design the curricula in the high schools for the large majority of the pupils who do not go to college but enter the trades or business directly from high school. One certainly cannot find fault with the desire to give this group, which is estimated by the United States Office of Education to be approximately two-thirds of the high-school graduates, the best possible preparation and training for their life work. However, I do believe one is justified in objecting to sacrificing the preparation of one-third of the high-school graduates who do matriculate in college in order to have a satisfactory program for the other two-thirds. It would appear that the high-school curricula and guidance could and should be designed to adequately meet the needs of all graduates.

It is the contention of some, if not most, of the specialists in secondary education that present high-school curricula do meet the requirements of all of the graduates. Studies are cited in which the conclusion is drawn that there is no correlation between subject matter taken in high school and performance in college. One may accept this conclusion if the high-school work is disciplinary and rigorous and provided the subject matter missed in high school is not a prerequisite for courses required in college. You can see readily that under such educational philosophy the high-school graduates planning to matriculate in engineering suffer most because usually it is supposed that they have completed mathematics through trigonometry or at least through advanced algebra.

The seriousness of this situation can be shown by the experience of my own institution, Oregon State College, during the academic year just past, and we feel quite sure our experience is not unique. In the fall term of 1951–52 56 per cent of the students who applied for admission to the Engineering School failed their mathematics qualifying examination and were placed therefore in the pre-engineering program to make up their mathematics deficiency. Of this group only about 25 per cent were salvaged.

The Engineers Council for Professional Development (ECPD) has done an outstanding service in the survey of engineering curricula and the accrediting of engineering schools. It now appears that the effectiveness of this work is being impaired by the lack of preparation of the students entering engineering courses. Therefore, it is suggested that we co-operate with the ECPD and urge it to make a study of the secondary educational programs which are offered to pupils preparing to enter the engineering colleges.

New Drive for Supersonic Wind Tunnel

A 180,000-horsepower supersonic wind tunnel drive is included in the General Electric equipment ordered recently by the National Advisory Committee on Aeronautics (NACA). The electric motor unit and a companion 110,000-horsepower drive will be installed in two supersonic wind tunnels at NACA's Ames Aeronautical Laboratory, Moffett Field, Calif.

The installation will be used to power a new 8-foot tunnel which will create wind velocities several times the speed of sound. The drive will consist of four 45,000-horsepower 720-rpm variable-speed a-c induction motors mounted in tandem on a single shaft to drive either of two axial-flow compressors. The motors will weigh more than 145 tons apiece and each will be the size of a small room. The 4-motor drive will have a peak 1-hour output of 216,000 horsepower and the system will use slip-regulator control. The second unit will be used at the Ames Laboratory's present 16-foot tunnel. Using three propellers operating on a single shaft, this tunnel will create wind velocities ranging from 350 to 920 miles per hour.

Research in a Defense Economy

J. E. HOBSON
FELLOW AIEE

Increased recognition is being given by the government and industry to the significance of organized research and its importance to our defense economy. However, there is still much waste of research manpower which is an important national resource, the preservation of which is vital to our national existence.

IT IS APPARENT to all of us that the economy in which we are living is different, unusual, artificial, and an economy of indefinite duration. It is headed, full steam ahead, toward an end we do not see, an end we have not planned, an end we may not want. While we struggle to maintain the highest standard of living ever existent anywhere, and to create more pleasures, more comforts, and greater security for ourselves, we also must move with us that part of the world that is yet friendly, and that part of the world that gives even lip-service to our deep-rooted ideals of freedom and supremacy of the individual. We must develop, support, stimulate, and lead those areas outside our country whose raw materials and labor are required to supply a measure of the fuel for our economic effort. We even must overlook passive and reluctant co-operation, and even outright antagonism at times. We must serve as the arsenal for a good share of the free world.

OUR DEFENSE ECONOMY

WHILE WE DO all of this, we must arm ourselves as no nation has ever been armed, with goods whose sole purpose is not the creation of wealth, but the destruction of wealth and human life; not the creation of comfort and happiness, but the generation of untold misery and suffering; goods which do not contribute to a higher standard of living, but goods which actually destroy it. It is a paradox of strength and weakness, of creation and destruction, of power and subordination. It is our present defense economy. We do not know why we have it, what we did to cause it, or when, if ever, it will disappear. Like Alice in Wonderland, we are greatly confused by the small things that suddenly become huge, and by the very large and important matters forced into insignificance. We can only accept this situation, struggle with and through it as best we can and hope for a happy termination.

Scientific skills and knowledge are rapidly becoming our most important national resource. We must use them with utmost effectiveness and zeal to defend our way of life, our freedoms, and our very existence while we strive at the same time to preserve the world's highest standard of living. This gigantic effort will tax the research brains and facilities of our country to their limits. Even now the united research endeavors of industry, government, private individuals, and research organizations present an imposing bastion for the safety of this nation. But this is not enough. All of us must labor to extend and intensify our system of organized research. Our efforts must not dwindle in ardor nor stop at any now-conceived goal.

Task forces of research scientists and engineers must be deployed in the field with skill. The battles of science must be as painstakingly planned as are the battles of men and machines. This is the job for organized research in a defense economy.

SHORTAGE OF RESEARCH PERSONNEL

THOSE OF US in that nonproductive field of research administration are much concerned these days about the supply of trained scientific research personnel. The supply of engineers and scientists already is short, and the source of that supply, graduations from colleges and universities, is diminishing. Enrollment in the engineering schools of the United States was 226,000 in 1948, according to a survey of the American Society of Engineering Education. Last year it was only 130,000, and it may drop to less than 50,000 within two years. We need at least 30,000 engineers from the colleges each year, but probably we will have only two-thirds of that number in 1952 and one-half of that number by 1954, unless the government acts to channel more high-school graduates to engineering colleges.

The Department of Defense estimates that the expanding research programs of its department and of the Atomic Energy Commission will probably absorb something like three-quarters of the national supply of technically trained personnel. The limiting factor to the expansion of those defense programs is definitely manpower and not funds. Present thinking seems to assume an inexhaustible source of dollars, but unfortunately we cannot increase the supply of research personnel by devaluation of the existing individuals; the laws of human reproduction do not work that way.

In this connection, we should be doing something about the training and use of foreign research scientists and engineers to contribute to our vast obligations of research for both government and industry. A plan now is under way to establish applied research institutions in Germany, both for the use of our industry and for the use of Western German industry. The preliminary survey for establishing research institutes in Western Germany will be made shortly by the directors of Southwest Research Institute, Battelle Memorial Institute, Armour Research Foundation, and Stanford Research Institute. Stanford Research

Essentially full text of an address made at the AIEE Great Lakes District Meeting, Madison, Wis., May 17–19, 1951.

J. E. Hobson is Director, Stanford Research Institute, Stanford, Calif.

Institute recently sent a team of engineers and economists to Italy to revitalize, we hope, the mechanical industries and production of Italy. A team of 15 engineers and economists will work eight months in Italy on the first phase of this study. Stanford has the assistance of George S. Armstrong and Associates, Armour Research Foundation, and Southwest Research Institute. The mission is headed by John Abbink, retired Board Chairman of the McGraw-Hill International Corporation.

If we cannot get dollars, goods, or fighting men from our friends, maybe we can get research and engineering brains and effort! I suggest we aggressively explore that possibility. With such co-operation from abroad, we can do more to help the future economy of the foreign country by training its scientific personnel in the approach, plans, and techniques of organized research than our exports of goods or gold ever will do.

PRESENT WASTE OF RESEARCH FACILITIES

Some of our best thinking and top-level planning should go into the efficient deployment of research men and facilities for the effective use of both industry and government, but I see little effective effort in that direction. In my opinion the present waste of research facilities and manpower is catastrophic, mainly due to lack of sensible research planning and direction.

The most favorable trend apparent in our research manpower situation is the increased recognition by government, industry, and even the public of the importance and necessity for research. That recognition is far more significant today than it was before World War II, or at any time prior to this date. Gradually we are becoming aware that the techniques, the know-how, the men in organized applied research, and the scientists engaged in fundamental research form our greatest natural resource, a resource largely developed in, and peculiar to, the United States.

If only we could use every research man and woman more efficiently! Dr. Eric Walker of the Department of Defense Research and Development Board in a recent talk in San Francisco referred a bit wistfully to the manpower directive attributed to Emperor Haile Selassie, who is supposed to have issued the following call to arms when the Italian armies invaded Ethiopia:

"The country is now mobilized. All men and boys able to carry a spear will report for active duty. Married men will bring their wives to do the cooking; men who are not married will bring any women they can find. The very young, the very old, and women with very young children need not report for active duty. Anybody else found at home after the issuance of this order will be hanged."

In an effort to improve the efficiency of our organization and also to contribute to the welfare and happiness of our staff members, we have had under way for 18 months at Stanford Research Institute a research study and investigation on research environment. With the assistance of a consulting psychologist, we are attempting to explore the multitude of elusive factors involved in maintaining a creative and stimulating research atmosphere. What we have been able to accomplish so far is more than a little uncertain, but we have been able to give real assistance to individuals, and through them to the research environment. It must be remembered that the individual characteristics of the researchers set the environment, and not vice versa. Research people must be considered as are other creative persons—artists, musicians, sculptors, political geniuses—and, perhaps, including a new type of temperamental creative person of which we have late and current evidence, the military genius!

In few, if any, other organizations is the quality of the end product so dependent upon the individual and co-ordinated efforts of the staff members as in research. The effectiveness of any applied research organization is determined almost solely by the individual men and women in that organization: their training, their experience, their inherent and acquired abilities, their aggressiveness, their stability as independent and creative searchers for truth, their ability to work in a team.

The pertinent conclusions from our studies of research environment are related clearly and directly to the facts that the average age of our staff of 350 or more persons is only 31, that a very large percentage of the staff had their initial experience in a military organization where they developed a dependence on a rather rigid line organization, and that inherently researchers are influenced strongly both by a desire for economic and professional security and by a desire to participate in an element of risk to avoid stagnation and routine work. Thus, there must be a proper balance between job delineation and the opportunity for exercise of individual initiative and versatility. Research people are somewhat professionally provincial because of limited experience in other areas, but they take great pride in self-sufficiency, cultivate independence, and resist interference and admitting the need for assistance. Further, the researcher tends to deal with minutiae and to overlook the broad over-all picture. These and other findings of our study undoubtedly are found in other research groups, particularly the younger, rapidly expanding organizations.

FUTURE RESEARCH POLICIES

Dr. Frank B. Jewett, Jr., of General Mills, discussed in a very able manner at the recent Northern California Research Conference the research policies which must be followed by industry in this defense economy. He pointed out that industrial policies in research must be paced for the long haul, they must be formulated with the view of indefinite continuation, and must be geared to support accomplishments in industrial research, provide a steady stream of basic research, and recognize a responsibility to aid in the supply of trained manpower. Research for defense must be done along with research in the immediate commercial interests of the company. Industry must take a large part of the load of defense research in a free enterprise system or the government will do it. Since these conditions may exist for decades instead of years, the policies of industrial management, particularly as they relate to research, must be designed to protect and preserve our economic and political system, not destroy it. It is

certainly not wise for individual companies to go all out for government-financed defense research and ignore research for commercial products and processes needed by the company and by our economy for the long pull. The flow of research and development in affairs of commerce must be maintained if not accelerated. Our commerce is the base upon which the future of the whole nation rests. Quoting Doctor Jewett, "Industry must solve its present problems without jeopardizing our free capitalistic society when the national predicament is over. The first responsibility of industrial research is to industry itself. Second is an obligation to mobilize a portion of its facilities in the national interest.

"Certainly the company that selects government research in those areas where it can gain knowledge that can be applied to its commercial activities will be way ahead of its competitors. It will have the know-how, will see potential commercial applications, will see impending competition, will train its research staff, will accumulate research facilities, will be in a much better position to shift to all-out military production if necessary . . . and will, of course, fulfill its obligation to the defense program."

No industry or company can afford not to take advantage of the present situation for its own selfish interests. Every company should explore carefully and thoroughly the opportunities for defense research contracts, whether or not those research and development contracts are related in any way to the present production of the company, and whether or not those research contracts are related to contracts for defense production.

EMPHASIS ON INDUSTRIAL RESEARCH

Dr. Lloyd W. Berkner, President of Associated Universities, related the following pertinent story in an address which he delivered at the National Electronics Conference in Chicago in 1947:

"During the past war a group of electronics manufacturers from the Chicago area asked for a conference with the Secretary of the Navy. They pointed out that they had enormous factory capacity, a good source of labor, and plenty of machinery. They were anxious to throw more of their facilities into the war effort. But the bulk of new electronics business was going to firms in the East! Why?

"As you all know, there was tremendous evolution in application and form of electronic equipment during the war. This was not a matter of whim—it was the result of the need to meet and forestall the evolution of enemy tactics. The source of this new equipment was the laboratory where the scientist and engineer joined with the tactician and strategist to devise the most effective means of combating each new or anticipated tactic. It was a matter of necessity, then, that the Army and the Navy turn to organizations whose research and development laboratories had the capacity, quality and vigor to provide the solutions needed, and usually the production contracts followed. Unfortunately for the equitable geographic distribution of such contracts, the majority of adequate industrial electronic laboratory facilities were at that time in the East.

"Here, then, is a specific example where the life of a community was adversely affected by a shortage in research and development. Here is an example of saturation in our regenerative system of progressive industry. Continued growth and welfare depend importantly on renewal and expansion of industry through constant generation and advance of ideas. It behooves the engineer, the business man, and the financier to protect his industry and his community, in proportion to his business and investment, with the safeguards of creative thinking involved by research and invention. Support of research is an economic matter required for the welfare of the industry. But it is also a cultural matter deserving the support of the whole community. Its planning requires initiative and effort from the financier, the educator, the professional man, and the merchant alike. We need here the same kind of foresight demonstrated by the pioneers who taxed themselves under the most adverse conditions to establish our universities."

RESEARCH—BASIC NATIONAL RESOURCE

May I repeat that a group of organized researchers, in industry, a university, or an independent organization, is an important community asset and a vital part of our basic national resources.

A Research and Development Board analysis of the distribution of defense industrial research contracts by region discloses some interesting facts with respect to the Pacific Coast area. The study was based on figures for the fiscal year 1949 and the figures may be different now; nevertheless, the relative percentages probably are still approximately the same. Although the Pacific Coast area had 10 per cent of the total United States population, it had 27 per cent of the total amount of industrial research contracts and 75 per cent of these were aviation research contracts. In nonaviation research contracts, the Pacific Coast is represented by 14 per cent of the total. In aviation research contracts, the Pacific Coast leads the rest of the country with 40 per cent of the total. The growth of research effort on the West Coast during and following World War II has been tremendous.

Wetmore Hodges is the authority for the statement that there are more potential revolutions on the horizons of more individual industries today than at any time in the last 30 years. It is of prime importance that we recognize the peculiar obligations and the particular opportunities presented to every form of industrial activity by the urgencies of our defense economy. Industry cannot avoid looking to research and creative engineering talent for help with realization of the ideal role industry can play toward more production with less waste.

This nation occupies 6 per cent of the land area of the world, has 7 per cent of the world's population; but it now produces 50 per cent of the world's goods and possesses 67 per cent of the world's wealth. Research must be the heart, the foundation, the life-blood of our present defense economy if we are to maintain this position; if we are to preserve our freedoms and our chosen way of life; if we are to maintain our hard-earned standard of living; if we do our duty to ourselves and, in particular, if we do our professional duty as engineers and research scientists.

Donald Ivan Bohn

Lamme Medalist for 1950

Donald Ivan Bohn, chief electrical engineer of the Aluminum Company of America, has been awarded the 1950 Lamme Medal "for his pioneering development and application of electrical equipment for controlling rectifying systems in the production of aluminum." Mr. Bohn is the 23rd recipient of the medal.

The Establishment of the Medal

A. H. KEHOE
FELLOW AIEE

ON MAY 16, 1919, a noted engineer of our Institute, but a very modest retiring man, received in the auditorium of the Engineering Building in New York the Edison Medal. The same man in 1923 at his Alma Mater, Ohio State University, was given the initial award of that university's Joseph Sullivant Medal. This latter medal is awarded once every five years for the most notable contribution by any graduate to the liberal, the fine, or the mechanic arts. The Ohio State ace, B. G. Lamme, a few days before the formal presentation of the Sullivant Medal, is recorded as saying of his honors that he was " enjoying it about as much as the early Christians enjoyed the prospect of being fed to the lions."

The Lamme Medal, established 1926

The 1919 Edison Medal award to Mr. Lamme was followed by a 5-year appointment on the Edison Medal Committee of the Institute. His death preceded the expiration of the assignment by but a few days. While the numerous contributions which B. G. Lamme made to our Institute, our industry, and our country are too broad and varied to be discussed here today, his long-term favorable reaction to the desirability of recognizing achievement through the award of suitable medals is worthy of reiteration. With that analytic skill which he used so successfully in his vocation, he saw certain important types of achievement which were not receiving proper recognition. So in addition to the medal he intrusted to the Institute, which we are presenting today, his will, among other things, provided for two other Lamme Medals. One covers attainments in the field of technical education; the second is restricted to technical graduates of Ohio State University. All three Lamme Medals have an obverse with this motto: "The Engineer views hopefully the hitherto unattainable." The reverse of each type of medal is distinctive.

Our award is restricted to members of the Institute who have "shown meritorious achievement in the development of electrical apparatus or machinery."

Great care was exercised in the establishment of our Medal between 1925 and 1929, first by the Committee on Award of Institute Prizes, and then by a special committee appointed by the Board of Directors, to have the award of the medal a recognition of the development of better equipment, as Mr. Lamme had intended.

The initial presentation for the year 1928 was made at the Summer Convention at Swampscott in June 1929 to Allan Bertram Field. The 1929 Lamme Medal was presented to Rudolf E. Hellmund in June 1930 just 21 years ago this week at the Summer General Meeting which was held here in Toronto.

Since then each year, a notable development has been recognized by the Institute in honoring some one of its members at each of the Summer Meetings. Of course there is the limitation that all worthy cases cannot be recognized by a single annual award and my personal wish is that such a condition will always be with us, for the good of all mankind, as well as the more selfish good of our profession. Progress, in the future, certainly lies along such a path.

Career of the Medalist

THOMAS D. JOLLY

MR. PRESIDENT, honored guests, members of the AIEE, ladies and gentlemen:

I believe I am safe in assuming that many of us here today are called upon more or less frequently to stand up on our feet and make a talk. Often enough, I expect, we would prefer to beg off by pleading a previous engagement

Full texts of the presentation and acceptance addresses given at the Lamme Medal ceremony held during the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951.

A. H. Kehoe, Chairman of the Lamme Medal Committee, is Vice-President, Consolidated Edison Company of New York, Inc., New York, N. Y.

Thomas D. Jolly is Vice-President and chief engineer, Aluminum Company of America, Pittsburgh, Pa.

or the press of other business. Believe me—that is not the case with me today.

This is one time when I feel nothing but pure, unmixed pleasure in being called upon to speak. I am not only delighted to have this assignment, but feel truly honored in having been asked to carry it out. This is one I have been waiting for!

The man whose career I have been asked to tell about is no ordinary person. He is, let me assure you, completely human—gifted with a hearty sense of humor, a dynamic and forthright personality, and a genuine love of life. But he has a great deal more than that in him. Once in a long while it is our privilege to come across an individual who has been blessed with a rare thing—something which transcends talent, and stands out above the accomplishments which some achieve by sheer hard work and diligent application. That "something" is hard to define, but the word that comes closest to doing it is "genius."

Genius, it seems, has a way of showing up early in those to whom it is granted. The man of whom I speak showed definite signs that his destiny was electricity before reaching the age of 12. He was still in corduroy knee-pants when he went to work for an electrician in his home town of Chicago and became highly proficient in repairing electric trains. The following year—this was 1909, mind you—he constructed two wireless sets, the second being a 1/4-kw job of the "rock crusher" type. It worked extremely well in the Chicago area, and according to the best available information it also did an efficient job of electrocuting the family cat.

Donald I. Bohn

After considerable private research I have also unearthed the fact that he built himself two automobiles before reaching the age of 16. The first had a wooden frame, and was powered by a 1-cylinder engine, rolling on four bicycle wheels. In 1912, he outdid himself by constructing a super-type car having a friction drive and twin engine, with motorcycle wheels and a steel frame.

In between going to school and indulging in prodigious amounts of shop work, he learned to play a variety of wind instruments, and at 18 began working his way as a saxophone player in various dance orchestras. After entering the University of Wisconsin, he joined the band, played the saxophone and bassoon, and wound up with a 2-month trip to the San Francisco World's Fair.

By his own confession, he had enough trouble with chemistry and surveying so that he enlisted in the Army in 1917. He saw much action in France, and was a lieutenant of artillery, in charge of wireless when discharged.

After being graduated as a Bachelor of Science in Electrical Engineering from Wisconsin in 1921, he was employed by the General Electric Company at Schenectady, N. Y., as a test engineer. He claims he was primarily a saxophone player even then, and only brought General Electric out of their 1921 depression as a sideline. But the electrical genius in him kept getting harder to suppress as time went on.

Since 1924, Donald I. Bohn has been an electrical engineer in earnest, and in the fullest sense of the term. In that year, he became associated with the aluminum industry—the largest user of electric energy in our country, and probably in the world. Since July 1, 1946, he has been the chief electrical engineer for Aluminum Company of America (Alcoa).

Donald I. Bohn took on a large assignment in his first days with Alcoa. He was placed in charge of operating a major hydroelectric system associated with a metal-producing plant having a 100,000-kw load. A great deal of experimental work in the electrothermal and electrochemical fields was carried on at this plant in those days. Within a short time he had devised a new and efficient bus arrangement of unique design for supplying large alternating currents to an electric-arc furnace being used there.

His ingenuity in improving or modifying conventional apparatus for special uses soon became apparent. In 1928, he was transferred to Alcoa's home offices in Pittsburgh as assistant to the chief electrical engineer. This brought him in close contact with a wide range of electrical problems, and he immediately tackled them with new approaches and ideas. Some of his important innovations involved mechanical details that perfected the operation of machinery; others involved broad, bold conceptions for attacking electrical problems.

As I look back, I recognize that all these problems required just one characteristic to intrigue Donald Bohn and get him started: they merely had to offer the possibility of being solved by a new approach.

In the years just before World War II, the Alcoa management became convinced that aluminum production should be greatly increased so the nation could meet anticipated needs. At that time, the question of the best type of a-c to d-c conversion was a matter of hot debate. The arguments in favor of the mercury-arc rectifier, over rotating equipment previously used, convinced Alcoa that it would be wise to depart from tradition. The company went ahead and bought 100,000 kw of mercury-arc rectifiers, despite the fact that there was no experience in this

country or abroad with such a batch of rectifiers. Many serious problems did arise, and no one deserves more credit for their solution than Donald Bohn.

One of these problems was interference with telephone communications in the surrounding areas. This was overcome by the multiphase displacement system, which eliminated or reduced to harmlessness the harmonics in the voice interference range. A second major problem was isolating rectifiers from the line in case of arc back, so as to relieve the supplying transformer from excessive short-circuit forces. This required perfection of a circuit breaker which would isolate the rectifier before the current could reach a harmful value. Donald Bohn conceived the idea of a new mechanism for such a circuit breaker. He built a full-scale model in his basement at home, and proved its ability to perform successfully. The high-speed circuit breaker is now the accepted standard for these purposes.

Those were not the only problems surrounding the use of mercury-arc rectifiers at that time. Another was finding a way of firing the ignitron type of rectifier by some other means than the use of rectifying tubes, because of the high tube maintenance cost. Donald Bohn stimulated manufacturers to perfect the static firing system which solved the problem and is now the accepted firing method.

His work in bringing the mercury-arc rectifier to a high degree of satisfactory performance was a major contribution to the war effort in World War II—more apparent when you consider that the aluminum industry alone used over 1,500,000 kw of rectifiers in the United States, and a like amount for the same purpose in Canada. Other electrochemical processes using direct current also adopted this or similar equipment.

During the 1930's, Donald Bohn also began directing much of his attention to the development of electric welding processes for joining aluminum. He was one of the early investigators of resistance welding for this purpose. He was among the first to work out the principle of simultaneous application of controlled pressure and controlled energy. He designed one of the first spot-welding machines to accomplish this job, and patented many devices and methods in connection with the process.

He has played an important part in the development of low-frequency induction heating, and has been instrumental in designing equipment for exploitation of this heating method.

Donald Bohn's versatility and inventive genius continue to bubble over. He has brought many significant improvements to the design of gas engines, and his innovations have recently resulted in the adoption of a radial design of engine for industrial use. One was a system of ignition employing an impulse generator of a new type to replace the older contact-breaking method of producing the spark. Alcoa has built a new plant in Texas employing 130,000 kw of these engines. Not only is it in successful operation, but the generating facilities are now being increased to slightly over 200,000 kw.

I have often heard Donald Bohn say this: "A mechanical engineer may not need to know much of the fundamentals of electricity, but every good electrical engineer must be at least a fair mechanical engineer." I can think of no better living example of the truth of that statement than Mr. Bohn himself.

My time is running out, and I shall touch only lightly on a few of the other achievements that mark the really amazing career of Donald Bohn as I know it. He has done such things as design a system for maintaining constant tension on coils of rolled metal during the rolling process; he has contributed important improvements to the design of meters for measuring large direct currents; he developed the first totally enclosed air-conditioned crane cab, with controls arranged for operation from a seated position; and he dreamed up a patented device for automatically producing and dispensing ice cubes from mechanical refrigerators. I sincerely say that his other accomplishments are too numerous to mention at this time.

No one here today is more proud than I am of the honor being done to Donald I. Bohn by this esteemed and honorable society. I believe he richly merits this accolade which the Institute has chosen to give him, for it truly can be said that he has done well in his chosen field, and enriched his fellow men by his contributions to it.

Power for Aluminum—Where

DONALD I. BOHN
FELLOW AIEE

I AM DEEPLY honored to have been chosen the recipient of this year's Lamme award. In receiving this medal, I cannot help but feel particularly proud, as well as extremely humble, as my name is added to the illustrious list of past recipients who have gained this honor. I gratefully accept this medal, not only for myself, but also as a symbol of the great contribution made by the electrical engineers of the aluminum industry.

At the turn of the century, the aluminum industry in the United States was about ten years old, and the yearly production at that time was about 1/3 per cent of the present figure. All the power for the aluminum reduction process was hydroelectric generation. Some 40,000 kw of d-c generation at Niagara Falls, followed by a similar amount of d-c hydro in Massena, N. Y., established a pattern for the growth of the industry for the first third of this century.

One cannot look at these early hydro developments without paying thoughtful tribute to the courage of the electrical industry in building these large d-c generators at that time. The Massena station is still in full and quite efficient operation, nearly 50 years after it was placed in service. Most of the original commutators are still in operation on these generators, their rating being 2,200 kw at 500 volts d-c.

Between 1912 and 1920 additional hydroelectric developments were made in Tennessee and North Carolina, totalling about 180,000 kw. Both of these projects were so located that alternating current was generated and transmitted, and rotary converters were required at the reduction plants. By 1932 the industry, still based entirely on

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hydroelectric generation for the reduction process, had installed generating capacity of 540,000 kw, which represented about 1½ per cent of the installed generating capacity in the United States.

Fundamentally, an aluminum reduction plant can be located wherever economical electric power is available. This is, of course, not the case with respect to power generated for industrial use, as in general it must be generated in the vicinity where the population and industries are located. Since the power cost for industrial use is, in most cases, a minor factor in the cost of the finished product, it is of little importance whether or not such power is obtained at low rates. The aluminum reduction industry was fortunate, therefore, in being able to use and develop low cost hydroelectric projects, even though located in sparsely settled areas.

This general pattern of expansion of the aluminum reduction industry probably would have continued indefinitely on this same basis, to the general economic advantage of the country, had it not been for the political events which started in 1932 and completely changed this basically sound picture. It was then that distinct changes in interpretation of the Federal licensing law began. Most of the desirable hydroelectric projects were, in fact, on streams which were not navigable, but it was soon discovered that practically any proposed project was determined to be on navigable water, even if sandwiched in between two natural rapids. Also, if a Federal license were deemed to be necessary, interpretation of the various provisions of such a license were found to make the project much less desirable than had been the case prior to this time. In this simple manner, therefore, the long range plans of growth of the aluminum reduction industry were instantly blocked. This development occurred simultaneously with the rapid upswing of Federally built hydroelectric projects.

The depression, which had been well maintained by various attacks on business and industry, was finally ended by World War II. The successful prosecution of this war made large quantities of aluminum essential. The expansion which followed increased aluminum production about six-fold during the ensuing four years. A large part of this increase was from steam-generated power used in government-owned aluminum plants, the power being made available as surplus from metropolitan areas. Nearly all the rest of the wartime government-owned plants were powered by hydroelectric developments and are still in operation.

Shortly before World War II, a major technical change in reduction plant power took place, this being the practically instantaneous obsolescence of rotary converters as a result of the advent of large mercury-arc rectifiers. The initial large installation of this type of conversion was made a few years before World War II and consisted of about 100,000 kw of multiple-anode rectifiers. A short time later, a new plant using government hydroelectric power employed about 200,000 kw of single-anode rectifiers.

The end of World War II may be truly said to have started a new era in this continuous struggle to obtain low cost power for aluminum reduction. There was practically no more government hydroelectric power available at satisfactory costs. Tennessee Valley Authority, for instance, again began polishing up its yardstick on a number of enormous steam plants. The Korean situation developed additional requirements, although the permanent capacity of the industry had expanded fourfold during the last ten years.

With this background, it is quite obvious why, for the first time in the history of aluminum reduction, except for war expansion, thermally generated electric power was employed. It was simply a matter of providing such generation, or severely limiting further expansion. The initial step away from hydroelectric generation involved a plant using natural gas in internal combustion engines, and rated 130,000 kw. This will be expanded to 220,000 kw by next year. Additional reduction plants are being installed, both steam- and gas-engine powered, using natural gas representing about 300,000 kw of new facilities.

Where do we go from here? This question is both political and economic and it would seem that there are three possible paths which the industry might follow:

1. The political climate of the United States may change so that present arbitrary restrictions on the development of privately owned hydroelectric properties will disappear.

2. In direct contrast to this desirable condition, the aluminum industry may be forced to expand its production with thermally generated electric energy. This would deplete our fuels further, of course, and higher aluminum costs naturally would result if such a course is followed.

3. A large part of the expansion of the aluminum reduction industry may be taken care of by low cost hydroelectric power outside the continental limits of the United States. However, this method also is tied in with the future political picture.

It is to be hoped that either the first or last of these paths may eventuate to the ultimate good of our country and the aluminum industry. In any event, you may all rest assured that the future will see ample supplies of aluminum, regardless of the political trend.

Electric Motors to Drive Oil Pumps

The largest electric motors and pumps ever built for oil pipe-line pumping service are being installed by the Texas Pipe Line Company, Houston, Tex., for an expansion of the 515-mile, New Mexico to Oklahoma crude oil line. Eight 3,000-horsepower 1,780-rpm induction motors and seven similar 1,250-horsepower units will add 100,000 barrels of oil per day to the pumping capacity of the pipe-line system. These motors use pressure-lubricated bearings, and are fully enclosed for ventilation from a filtered fresh air source to minimize fire hazard. Despite their great horsepower, the motors will be started across-the-line at full voltage, and they are designed for specially low starting current to minimize the disturbance to the power systems.

Electrical Conductivity of Cadmium Sulphide Exposed to Pulsating X Radiation

J. E. JACOBS

THE WORK outlined in this paper is the basis for the application of cadmium sulphide in the high-speed automatic X-ray inspection of a variety of products such as canned goods, fuse trains, and other homogenous substances.

The cadmium sulphide crystal, because of its high amplification and absorption of X radiation, for some time has appeared to be an ideal device for application to this type of inspection problem. One defect of the crystal—namely, too long a time in reaching a stable value of output current following irradiation—has hitherto been the principal obstacle in applying detectors of this type in practical inspection equipment.

The cadmium sulfide crystal is being used in equipment for fast X-ray inspection of homogeneous substances. The equipment used and the theory utilized in the design of the equipment are described in this article.

Previously reported work[1-4] with two exceptions[2,4] has been concerned with the average value of the conduction current. Use of the rate of change of crystal conduction current when subjected to pulsating X radiation minimizes many of the previously objectionable properties of these crystals when used as detectors of low-intensity X radiation.

All cadmium sulphide crystals used for these experiments were obtained from Dr. Rudolf Frerichs of the Physics Department of Northwestern University. These crystals were produced by an ingenious method devised by him.[1] The crystals selected for use were those that appeared to be either large single clear crystals, or bundles of the same having a light yellow appearance. The thickness of cadmium sulphide needed to absorb 99 per cent of the radiation used is only 0.04 millimeter. All crystals were chosen to be at least one millimeter thick.

The crystals were mounted by use of a commercial preparation of colloidal graphite in alcohol. This preparation served the dual purpose of cementing the crystal to the metal electrodes while, at the same time, providing electrical contact to the ends of the crystal. The crystals so mounted were placed in a light-tight box, having a beryllium window, of such a thickness as to give 95 per cent transmission at the wavelength used.

Practically all X-ray generators in use today give a pulsating output of X radiation. The generator used for these experiments was a self-rectifying one, using a copper target tube having a beryllium window. The tube was operated with a peak tube voltage of 14.7 kv and an average tube current of 4.0 milliamperes. The target-crystal distance was maintained at 25 centimeters. Variation of the intensity of incident radiation on the crystals was accomplished by means of nickel filters having a measured thickness of 8.4×10^{-4} centimeter. Use of the nickel filters and low applied voltage resulted in an essentially monochromatic beam when more than three thicknesses of nickel were in the beam, as shown by Figure 1. It should be noted that the intensity scale on Figure 1 is logarithmic, which tends to amplify the background. A standard Geiger-Mueller tube having a known efficiency at this wavelength was used to calibrate the generator.

The crystals were connected in the basic crystal circuit shown in Figure 2. The voltage rise produced by the conduction current across a resistor connected to the output terminals was measured by an a-c amplifier having a measured gain of 45,000. The output of the amplifier was fed

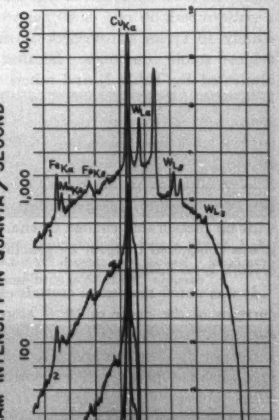

Figure 1. Spectrum of Cu target tube as nickel filters are added to beam. Curve 1—No filters; curve 2—three filters; curve 3—six filters; curve 4—nine filters; curve 5—12 filters. Tube voltage 14.7-kv peak; filter thickness 8.40×10^{-4} centimeter

Abstract from a dissertation submitted in March 1950 to Northwestern University, Department of Electrical Engineering, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

J. E. Jacobs is with the General Electric X-Ray Corporation, Milwaukee, Wis.

Grateful acknowledgment is made to Dr. Jacobs' advisor, Professor R. W. Jones of the Electrical Engineering Department at Northwestern University; to Dr. Rudolf Frerichs of the Physics Department for furnishing not only all of the crystals used but for valuable advice on techniques; and to Dr. J. C. M. Brentano of the Physics Department for his assistance and encouragement in the preparation of this paper.

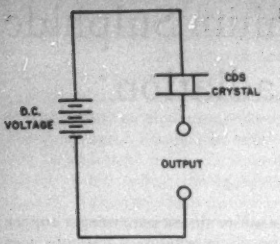

Figure 2. Basic crystal circuit

Table I. Time Delay in Response of Crystals Using the Average Value of Crystal Current

Crystal Number	Elapsed Time Between Irradiations	Time to Reach 95 Per Cent of Final Value of Current After Application of Beam
1	20 minutes	5 minutes
	55 minutes	7 minutes
	16 hours	12.5 minutes
2	1.0 minutes	10 minutes
	1.0 hours	1 hour
	12.0 hours	3 hours

Note: Incident intensity = 9,200 quanta per second

to a peak voltmeter which served to run a Leeds and Northrup Speedomax recorder. A cathode-follower stage was provided to drive an oscillograph with the output of the a-c amplifier. With the exception of the crystals used for noise measurements, only those having a resistance in the dark exceeding 10^{15} ohms were used.

By use of the a-c or time derivative component of crystal current, one in effect measures the initial slope of the response curve. With pulsating X rays this reaches a stable value in a fraction of a second. Specifically, when a pulse repetition rate of 60 per second is used, approximately 10 cycles are needed, as shown by Figure 3, to achieve stable conditions. Because of this advantage, as illustrated by Table I, and others to be noted later, all work reported in this article was carried out using the a-c component of crystal current. The a-c amplifier used for this work had a low-frequency cutoff at 40 cycles per second.

In an attempt to gain some idea of expected crystal life, two crystals were subjected to total quanta exceeding 10^{12} with no measurable change in characteristics. From this it was concluded that, for all practical purposes, life of the crystals is no problem.

It was noted that some crystals exhibited random noise currents of the order of 10^{-11} ampere when the applied d-c field exceeded 150 volts per centimeter. Others, while not showing this characteristic, exhibited an erratic multiplication process when irradiated. Oscillograms of these undesirable characteristics are shown in Figures 4 and 5. Comparison of these figures with Figure 3, which was taken with the same applied polarizing field and incident irradiation, shows the desirability of avoiding this type of crystal.

In an attempt to determine the cause of these undesirable characteristics, Laue transmission patterns of the crystals were made. It was found that the crystals exhibiting the noise and erratic multiplication processes showed evidences of lattice distortion as evidenced by asterism or a radial streaking in the Laue pattern. The crystals having none of these undesirable characteristics had Laue patterns completely free of any signs of asterism.

In an attempt to eliminate this condition, both types of crystals were annealed in a nitrogen atmosphere. No change in crystal characteristics was noted following annealing. However, following annealing in an oxygen atmosphere, it was noted that the ratio of output current to incident quanta for the crystals was increased by a factor of 100. Crystals of the type shown by Figure 3 now exhibited the same characteristics as shown by Figures 4 and 5. It also was noted that the crystals had become darker following annealing in oxygen. These annealed crystals were placed on life test and found to retain the altered characteristics after 10^{12} quanta.

Over the X-ray intensity range used for these experiments (100 to 100,000 quanta per second) it was found that the d-c component of crystal current varied approximately linearly with intensity, while the a-c component

Figure 3. Response of cadmium sulphide to suddenly applied X rays. Crystal in light-tight box. Incident quanta is 3×10^3 per second. Peak current indicated 1.6×10^{-9} ampere

Figure 4. Noise currents generated in absence of radiation by crystal having lattice strain as evidenced by asterism in Laue patterns

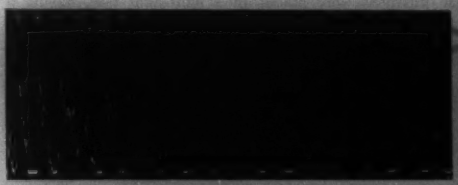

Figure 5. Erratic multiplication processes evidenced by crystal exhibiting lattice strain. Incident quanta is 5.1×10^3. Maximum current amplitude is 8.1×10^{-10} ampere

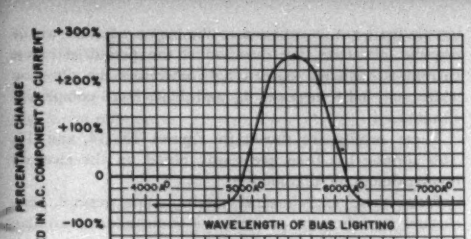

Figure 6. Variation of apparent crystal multiplication with wavelength of applied bias lighting. Incident X-ray intensity—2.5×10^4 per second. Bias light intensity adjusted to give 1×10^{-8} ampere of crystal current

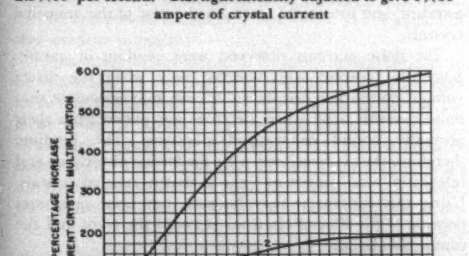

Figure 7. Increase in apparent crystal multiplication produced by bias light having wavelength of 5,200 angstroms. Incident intensity: Curve 1—8×10^3 quanta per second; curve 2—16×10^3 quanta per second; curve 3—33×10^3 quanta per second; curve 4—41×10^3 quanta per second

varied as the square of the incident intensity. Table II shows that the individual crystals' sensitivity to X radiation vary by a factor of approximately 100. In this intensity range the a-c component is approximately one-thousandth that of the d-c component. At higher intensities the a-c and d-c component approach each other in magnitude and the a-c component ceases to vary as the square of the incident intensity.

The term 'apparent multiplication' as used in Table II is defined for this article to be the ratio of electrons transported across the crystal to incident X-ray quanta. As previously noted, all crystals were of such a thickness as to assure that practically all of the incident quanta were absorbed. For these experiments no attempt was made to measure the yield from primary ionization of the crystal by the X-ray quanta.

Use of the a-c component of crystal current permits the introduction of a secondary illumination which will alter greatly the crystal characteristics. For these experiments the secondary illumination was produced using Wratten filters and a type-47 pilot lamp energized by batteries. The crystal current that flowed as a result of this light in the crystal was of constant magnitude and, hence, did not appear in the output of the a-c amplifier.

The effects of this light on the output current of a crystal being irradiated with X rays is very wavelength dependent, as shown by Figure 6. It was found that light having a maximum intensity at 5,200 angstroms produced an increase in the observed current for a given X-ray intensity. Red and blue light decreased the observed current for the same intensity.

The amount the output was increased by the light depended on the amount of light applied, as well as the incident X-ray intensity, as shown in Figure 7. The use of green light to increase the output current in this manner is limited by the appearance of random noise currents when the level of green light becomes excessive. This is illustrated in Figure 8, which shows the type of noise generated by this phenomenon.

Another advantage of superimposing green light is the reduction of the time necessary to reach stable operating conditions following the application of X radiation. Figure 9, which was taken under identical conditions as those of Figure 3 except that for Figure 9 green light was used, shows this effect. To achieve optimum results from the use of green light illumination, it was necessary to adjust the intensity of the green light as the intensity of the X rays was changed.

When the crystals were scanned along their major

Table II. Crystal Detection Characteristics

Crystal	Incident Quanta per Second	Observed D-C Current, Amperes	Apparent Multiplication	Ratio of A-C to D-C Component
1	6.15×10^3	2.3×10^{-4}	2.3×10^7	3.91×10^{-4}
2	1.09×10^4	7.0×10^{-4}	4.02×10^7	4.71×10^{-4}
3	5.16×10^3	2.3×10^{-4}	2.79×10^7	2.87×10^{-4}
4	9.2×10^3	5.5×10^{-4}	3.74×10^7	2.91×10^{-4}
5	9.25×10^3	1.4×10^{-4}	9.46×10^6	2.86×10^{-4}

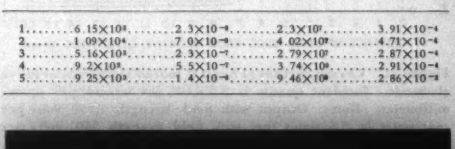

Figure 8. Noise currents generated by excess green light. Incident X radiation is 4.6×10^3 quanta per second. Maximum peak current amplitude is 6.2×10^{-7} ampere

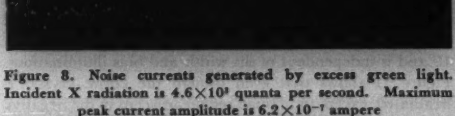

Figure 9. Decrease in response time when green light is used. Incident intensity is 3×10^3 quanta per second. Maximum peak current amplitude is 3.2×10^{-8} ampere

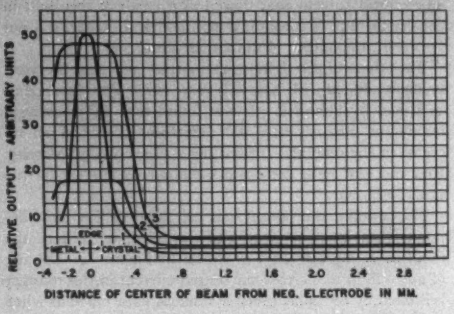

Figure 10. Variation in crystal current as crystal is scanned with narrow beam. Curve 1—beam width 7.6×10^{-3} millimeter; no light bias applied. Curve 2—Beam width 0.5 millimeter; no light bias applied. Curve 3—Beam width 0.5 millimeter; green light bias applied

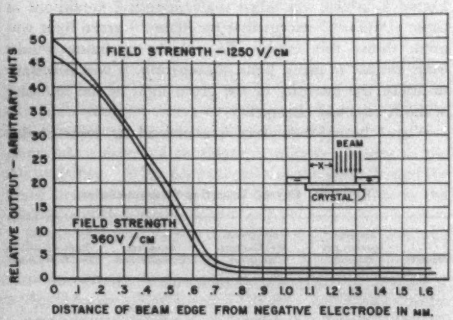

Figure 11. Crystal current as beam is moved away from negative electrode. Incident quanta is 3.3×10^4 per second per square millimeter. Note: Output with field strength 1,250 volts per centimeter is 3.6 times that with field strength 360 volts per centimeter. Scale expanded to show similar slopes

axis by a narrow beam, it was found that the maximum output is obtainable only when the region adjacent to the negative electrode is irradiated. This is shown in Figure 10 and is independent of slit width and bias illuminations. Figure 11 shows that even though the entire crystal is irradiated, except for a small region adjacent to the negative electrode, very little current flows. From this it may be seen that the region adjacent to the negative electrode must be irradiated to achieve maximum output from these crystals.

When the irradiating beam was confined to a narrow region adjacent to the negative electrode, blocked for a period of time by a lead shutter and then suddenly applied, a current in excess of the steady-state value was observed for a short period of time. Figure 12 shows this phenomenon observed when the crystal is in the dark. If secondary illumination is applied to the entire crystal while the irradiating beam is confined to the region adjacent to the negative electrode, the duration of the period of excess current is changed. Green light decreases the duration while red light increases it and blue light completely eliminates it.

These results are shown in Figures 13, 14, and 15. This surging has been previously noted on the electron bombardment of diamonds.[5,6]

From these experimental results, some general conclusions regarding the properties of semiconductors similar to cadmium sulphide may be drawn.

Random noise currents of the magnitude observed here, as well as erratic multiplication processes, arise in crystals having lattice defects. In the case cited, these lattice defects were attributed to lattice distortions, as evidenced by asterism, and interstitial atoms in the case of the annealed crystals.

The noise currents observed were random in nature. Since this current was observed only when the direct voltage exceeded a certain value, one may speculate that noise currents arise when electrons are pulled from their normally bound or trapped positions. The binding, therefore, that is associated with the lattice distortions and interstitial atoms is not as tight as that in normal crystals. Using this concept it may be said that noise originates because of the flow of electrons between the traps and the conduction band.

When the crystals are annealed in oxygen, the sulphur is replaced by the oxygen giving rise to free sulphur atoms in the lattice. These sulphur atoms apparently account for the increase in apparent crystal multiplication observed following annealing. Kallman and Warminsky[7] have reported similar observations of the effects of impurities on crystal output when using the crystals to detect alpha particles.

The square law relationship between the a-c component of crystal current and intensity may be explained as follows: The magnitude of the a-c component over this

Figure 12. Surging when negative electrode is suddenly irradiated by X radiation. Crystal is in light-tight box

intensity range was approximately one-thousandth that of the d-c component. This is to be expected when one considers the relative times involved between the repetition rate of the X-ray source of 60 pulses per second and the time to reach 95 per cent of final value for the d-c component of crystal current. In some crystals tested, the difference was in the order of 10^3.

This means that for all practical purposes the pulse of

X rays may be considered as a square pulse as far as the crystal is concerned.

At the time the X-ray pulse stops, the electrons in the conduction band start to recombine with the traps according to the relation

$$\frac{dn}{dt} = -bn^2$$

where n is the number of electrons in conduction band when X ray ceased, and b is the recombination coefficient. This means then that the a-c component should be proportional to the square of the number of electrons. From measurements of the average value of crystal current, it is known that the number of electrons present in the conduction band is a linear function of intensity; therefore, the a-c component should be proportional to the square of the incident intensity.

Explanation of the negative electrode effect appears to be as follows: In the region adjacent to the negative electrode the field strengths are great enough to permit the large values of apparent crystal multiplication observed. These fields arise from the presence of positive holes in this region. These holes are formed when the electrons are ejected from the filled band by irradiating the crystal; the electrons in the conduction band are swept out of this

Figure 13. Surging observed when green light secondary illumination is applied under conditions of Figure 12

region by the polarizing field leaving the positive holes. The positive space charge adjacent to the negative electrode reduces the field over the rest of the crystal so that the large values of apparent crystal multiplication cannot occur in these regions. It was found that the entire crystal, with the exception of the region adjacent to the negative electrode, could be irradiated by X rays, yet the current was limited to low values by this space charge effect.

The surging observed is believed to be the result of alteration of the field within the crystal by trapped electrons.[5] The electrons which are raised to the conduction band by the X radiation move towards the positive electrode, leaving a net positive charge behind them. If the radiation is not upon the negative electrode, the resultant positive space charge quickly reduces the conduction current to a low value.

The surges of current observed when the X radiation is applied suddenly to the negative electrode appear to be related to the process of filling the traps. The magnitude of the surge, being a function of the bias illumination, is thus dependent upon the initial condition of the traps.

Figure 14. Surging observed when red light bias is applied to crystal under conditions of Figure 12

Figure 15. Surging observed when blue light bias is applied to crystals under conditions of Figure 12

Apparently the red light bias empties the traps, resulting in a current surge of appreciable duration. On the other hand, green and blue light acts to fill the traps and thus reduce the surging effect.

In all crystals tested, currents of over 10^8 times that resulting from primary ionization of the crystal by the X radiation were observed. The mechanism postulated to explain this phenomenon must account for these additional electrons.

As pointed out by Frerichs,[3] when an electron is lifted to the conduction band by irradiation and leaves the crystal at the anode, another electron enters at the cathode. The resultant current is given by

$$i = ev(P/l)\nu$$

where

v is the mobility of the electron
P is the potential applied
l is the distance between electrodes
ν is the lifetime of the hole

If the lifetime of the hole is long, then an electron chain results which will give the large values of secondary currents observed.

Using the model which has been described in this article, all experimentally observed phenomena may be explained.

REFERENCES

1. The Photoconductivity of Incomplete Phosphorus, **R. Frerichs.** *Physical Review* (New York, N. Y.), volume 72, October 1947, pages 594–601.

2. The Cadmium Sulphide X-Ray Detector, **R. Frerichs.** *Journal of Applied Physics* (New York, N. Y.), volume 21, number 4, April 1950, pages 312–7.

3. On the Conductivity Proposed on CdS Crystals by Irradiation with Gamma Rays, **R. Frerichs.** *Physical Review* (New York, N. Y.), volume 76, December 1949, page 1869.

4. Detection of X-Ray Quanta by a Cadmium-Sulphide Crystal Counter, **S. G. Zisso, J. B. Platt.** *Physical Review* (New York, N. Y.), volume 76, September 1, 1949, page 704‡

5. Electron Bombardment Conductivity in Diamond, **K. G. McKay.** *Physical Review* (New York, N. Y.), volume 74, 1948, page 1606.

6. Removal of Space Charge in Diamond Crystal Counters, **A. G. Chynoweth.** *Physical Review* (New York, N. Y.), volume 76, July 15, 1949, page 310.

7. Determination of Energy of Single Particles from Change in Conductivity of CdS Crystal, **H. Kallman, R. Warminsky.** *Research* (London, England), volume 2, number 8, 1949, page 389.

Steady-State Analysis of Magnetic Amplifiers

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TO DATE, several methods have been introduced to compute the output currents of self-saturating magnetic amplifiers. These analyses are based either on a number of restricting assumptions, such as idealized magnetization curves, or are cumbersome to perform, such as a point-by-point integration. The basic method proposed in this article is between these two extremes; it consists of approximating the magnetization curve by a series of straight lines. Over each region of the magnetization curve, represented by one straight line, the reactor behaves like a constant inductance whose magnitude is proportional to the slope of this line. As the reactor magnetization varies from one region into an adjoining region, the equivalent fixed inductance changes abruptly from one value to another.

Application of the straight-line method converts the original set of nonlinear differential equations for the particular amplifier into several sets of linear equations, each set applying to one region of the magnetization curve. These differential equations are readily solvable, and the equation constants can be obtained by numerically satisfying the initial and boundary conditions at the juncture of the various regions.

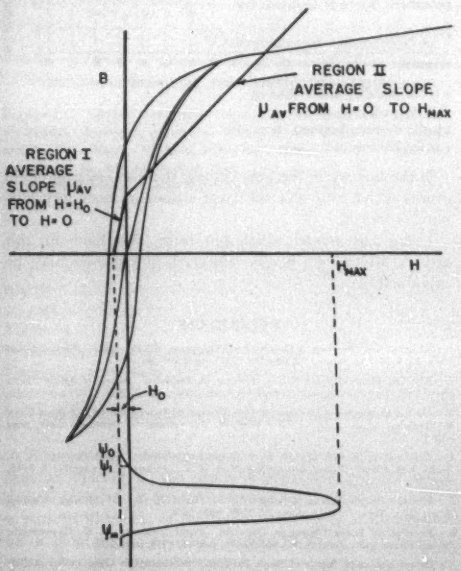

Figure 1. Operation on two slopes for simplified analysis

Accurate results were obtained from this analysis but the computations required were still excessive. Therefore, a simplified procedure was investigated. It was found that accurate values of load current could be computed on the basis of a saturation curve with two regions but with the slopes of each region dependent upon the average value of the slope of the magnetization curve as shown in Figure 1.

For example, with the value of d-c magnetization in the negative region as shown in Figure 1, the magnetization curve is divided into region I with slope equal to average μ between $H=H_0$ and zero, and the slope in region II equal to the average μ between $H=0$ and $H=H_{max}$. To facilitate the computation of the average value of slope, the variation of μ versus H is approximated by an exponential function. For example, for a hypersil cored reactor, the equation used was

$$\mu = (120e^{-0.7H} + 0.11) \times 10^3$$

The average value of μ between two values of H therefore can be determined easily.

With a knowledge of the average value of μ, and some curves which simplify the calculation of the output current, the transfer curves may be computed easily. For all values of d-c control current the amplifier is considered to operate in a single region of operation. For negative values of direct current the flow of output current prior to the $H=0$ is assumed negligible but it causes a delay shown as ψ_1 in Figure 1. The results, using the simplified method, were accurate and obtained rapidly.

The half-wave circuit discussed previously has limited application, the more practical types being the full-wave and doubler circuits. A brief study of these circuits reveals that they basically consist of two half-wave magnetic amplifiers coupled through a common load. The d-c outputs of these circuits are very nearly equal to twice that of each half-wave unit, but the magnitude is influenced by two factors:

1. Leakage current in the reverse direction of the rectifiers.
2. Overlap of the conduction period of each reactor, which results in simultaneous conduction of both reactors.

Each of these effects which tend to reduce the amplifier current can be computed. Accurate computation of the output currents of these types of amplifiers is therefore possible.

Digest of paper 51-72, "Steady-State Analysis of Self-Saturating Magnetic Amplifiers Based on Linear Approximations of the Magnetization Curve," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22-26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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The work described in this article was performed in conjunction with a thesis program at the Polytechnic Institute of Brooklyn (N. Y.).

Excitation System for a Synchrotron

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THE EXCITATION of a 70 mega-electron volt synchrotron magnet involves single-phase supply of loss energy to a tuned circuit, usually resonant at 60 cycles, wherein approximately 3,000 kva are circulating. This resonant circuit has a X_L/R ratio or Q of approximately 100, thus the frequency sensitivity of the circuit is quite great, and it usually is considered necessary that the input frequency be held within ± 0.3 cycle of the magnet circuit resonant frequency.

A complicating factor in supply of the magnet circuit is that the resonant frequency is not an absolute constant, being dependent on the saturation level of the iron and also on operating temperature of the tuning capacitors. The latter factor is a variable during lengthy operating periods, so that exact resonance to a fixed input frequency usually is not obtained except for short intervals.

The connection of such a load to a small power system without interconnections to other systems often is not practical due to known frequency swings beyond the stated tolerance. It is possible, however, to supply the magnet from an a-c generator, motor-driven through an adjustable-speed magnetic drive, the latter being controlled automatically through electronic circuits such that the generator speed and output frequency is always at a value to induce resonance in the magnet circuit. Such an arrangement offers the following advantages: 1. independence of fluctuations in power-line frequency; 2. automatic adjustment of frequency to the resonant value independent of capacitor temperature or saturation level changes; and 3. ease of starting the equipment, despite the considerable reduction of resonant frequency of the magnet circuit at low excitation levels.

An electronic control for the field excitation of the exciter also was provided which permitted automatic maintenance of accurate resonant circuit current level for providing the desired control of rotating electron energy, or X-radiation output of the synchrotron.

The magnetic drive is V-belt driven by an induction motor of 125 horsepower and the drive is directly connected to the 62.5-kva alternator. Normal output frequency with full excitation of the magnetic drive is designed as 66 cycles. Thus, normal operation somewhat below 60 cycles is in a region of good control characteristics.

At resonance the highest value of circulating current flows in the secondary circuit of the magnet. From the primary side the circuit appears to be parallel resonant, and a minimum primary current flows. Since the circuit appears resistive this current will be in phase with the applied primary voltage, and with resonance established the primary and secondary currents should be theoretically at 90 degrees in phase. It is the function of the electronic frequency-control circuits to maintain the generator speed so that magnet resonance and the expected current phase relations will be maintained.

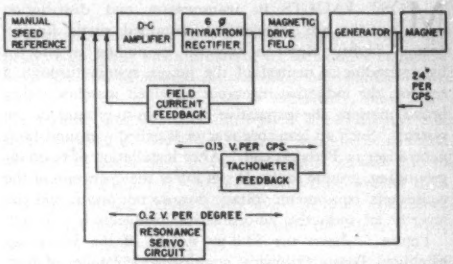

Figure 1. Block diagram of the complete frequency control system

A block diagram of the resonant frequency control system is presented in Figure 1, along with certain data on performance sensitivity. The phase detector in the resonant frequency servo is conventional, being of the balanced modulator type, and gives an output of 0.2 volt per degree of phase shift between primary and secondary magnet currents. This is sufficient, after amplification, to control the rectifier supplying the magnetic drive field so that the frequency is forced to the resonant value and held there within $\pm 1/3$ per cent or better. Because of the large inductance of the field, the inertia of the rotor of the magnetic drive, and the time lag inherent in the response of the synchrotron magnet, several antihunt networks have been introduced into the feedback loops around the control servo circuit. Under transient upsets due to sudden voltage surges applied to the driving induction motor, or to sudden frequency shifts, the desired 90-degree resonant phase angle is held within ± 5 degrees of the steady-state value.

The system is started by selection of the desired level of excitation of the magnet on the excitation control and by pushing the start button for the driving motor. Even though the resonant frequency of the system is low due to the low saturation of the magnet, the resonant-frequency servo adjusts the speed and frequency of the generator continuously as saturation occurs in build-up, and the speed of the generator advances in step with changes in resonant frequency until the operating condition and excitation level are reached. By this combination of excitation and frequency control large in-rush currents under off-resonance conditions are avoided.

Digest of paper 51-181, "A Variable Frequency Excitation System for a 70-MEV Synchrotron," recommended by the AIEE Committee on Nucleonics and approved by the AIEE Technical Program Committee for presentation at the AIEE Great Lakes District Meeting, Madison, Wis., May 17-19, 1951. Not scheduled for publication in AIEE *Transactions*.

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Practical Experience with Resonant Grounding

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MOST FAULTS in transmission and distribution systems are transient or sustained single line-to-ground faults. Resonant neutral grounding is effected by grounding a neutral of the power system through a reactor, the inductive reactance of which matches within broad margins the capacitive reactance-to-ground of the system. Such an iron core reactor is called a ground-fault neutralizer or Petersen coil. After installation of resonant grounding, ground faults do not affect the operation of the consumers' equipment, voltage dips do not occur, and the severity of inductive co-ordination problems is reduced.

Figure 1 shows the 34.5-kv system of the Wisconsin Michigan Power Company comprising 252 miles of line, to which as much as 101 miles of a neighboring utility may be added. The system supplies 12 paper mills with partial or all the power requirements. Voltage dips are extremely objectionable to such industries. A ground-fault neutralizer rated for continuous operation and composed of a single-phase Petersen coil and a zig-zag 3-phase reactor now protects the entire system.

Resonant neutral grounding was installed early in 1946 and has been in service since then without any maintenance expense. Prior to 1946, it was necessary to dispatch several crews during storms to repair and keep in service the 34.5-kv transmission and substation equipment. Very little, if any, transmission line trouble is experienced now.

Resonant grounding has reduced greatly the number and duration of outages. An average of 40 per cent reduction in the number of outages per year has occurred during the 2-year period after 1946. In general, the reduction in the number of severe faults can be attributed to the gradual elimination of damages which happened to conductors and insulators when the system was operated ungrounded. The Petersen coil prevents the development of arcing grounds. On sustained ground faults, the residual fault current is reduced to relatively small values that produce little damage.

During the 1946–50 period, 197 operations of the Petersen coil occurred. An analysis of the causes of ground faults indicates that 46.2 per cent were due to lightning; the known causes of the remaining ground faults were, in the order of their frequency, insulation, wire failures, high wind, and structures. An analysis of the duration of each fault shows that 83.3 per cent were instantaneous, 1.5 per cent lasted up to 5 minutes, 4.5 per cent between 5 and 30 minutes, 7.6 per cent from 1/2 hour to 3 hours, and 3.1 per cent more than 3 hours. The chart of the ammeter recording current through the ground-fault neutralizer during a sustained fault of 6 1/2 hours duration is reproduced in Figure 2. The great improvements brought about by resonant grounding are evident from a comparison of outages before and after the acceptance tests. The number of disconnected mile-hours, because of ground faults, during the year before the installation of the new equipment was 381.9; the average per year for the first two years afterwards was 72.5.

Resonant neutral grounding is an effective and most economical method of improving continuity and reliability of service. It provides protection from transient and sustained ground faults and needs little attention since resonant tuning is not necessary. Systems so protected can be operated for hours with sustained ground faults

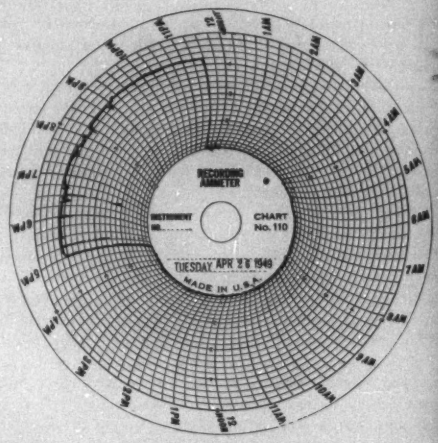

Figure 2. Chart of recording ammeter, indicating sustained ground fault of 6 1/2 hours duration

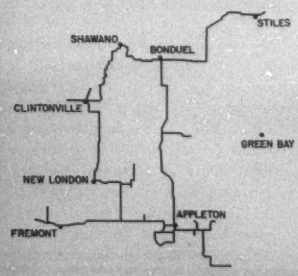

Figure 1. 34.5-kv system, Wisconsin Michigan Power Company

Digest of paper 50-224, "Practical Experiences with Resonant Grounding in a Large 34.5-Kv System," recommended by the AIEE Committee on Protective Devices and approved by the AIEE Technical Program Committee for presentation at the AIEE Fall General Meeting, Oklahoma City, Okla., October 23–27, 1950. Published in AIEE *Transactions*, volume 69, part II, 1950, pages 1401–06.

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Dynamic Strain Measurement

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DYNAMIC STRAIN measurement is an essential part of modern mechanical design. While the measurement of strains in parts of machines and structures under actual conditions of operation and loading is indispensable to the mechanical engineer, it is interesting to the electrical engineer because electrical methods are employed that call for many modern techniques.

Although the purpose of this article is to discuss the electrical methods involved and the equipment employed in dynamic strain measurement, a brief preliminary statement as to why such measurements are important is appropriate.

The actual measurement of dynamic strain in machines and structures is often of great importance for the following reasons:

1. Strains due to superimposed vibration may be relatively large. Frequently these vibratory strains are difficult or even impossible to calculate.
2. Structures may be too complex to permit accurate or practical mathematical analysis.

The necessity for dynamic strain measurement is increasing rapidly for several very apparent reasons. In the first place, the gap between safety and economy is forever being shortened, particularly in such machines as aircraft that must be made both light and reliable. As factors of safety are reduced, factors of ignorance must come down also; thus it becomes increasingly necessary for us to know exactly what loads materials will stand and what strains actually exist.

Dynamic strain measurements are becoming increasingly important as the gap between safety and economy grows smaller in modern engineering design. The electrical methods described here are used for strain measurement under actual operating conditions.

A second reason for the growing importance of dynamic strain measurement is that, because modern machines operate at higher speeds and modern structures are subjected to sharper impacts, the strains due to vibration and impact become more important. There are many instances in both machines and structures where strains introduced by vibration will greatly exceed strain due to static load. Machines and structures must be designed for vibration strain rather than static strain. The calculation of vibration amplitudes, modes, and frequencies is often very difficult so measurements must be made under actual operating conditions.

Take, for example, the case of the locomotive side rod. The steam locomotive comes down from a previous age before high speed was a problem, yet locomotive engineers were the first to realize the necessity of dynamic strain analysis. From a background of experience, these engineers know that side rods must be of a certain size and shape to perform. By actual dynamic measurements made at least 15 years ago, it was found that strains due to vibration in a side rod were often many times greater than calculated strain. How much more do such conditions exist in an aircraft propeller, an engine mount, or a wing strut!

The aircraft designer does not have the background of experience to rely upon as the locomotive engineer, and he works with smaller margins. Without the ability to measure strain in actual operation of his product, further advances in the development of machines would be stalemated, and few people who are not working in the frontier zones of machine design realize just how true that statement is. Without the ability to measure dynamic strain our standing in the future world would, indeed, be in great jeopardy.

Dynamic strain measurements are made by the use of electric strain gauges which are attached at points where strains are to be measured and which are connected to suitable recording instruments. In this manner, continuous records of strain against time are made as the members under investigation are loaded.

The recording instrument is generally some form of oscillograph, because rapid variations of strain usually are encountered. The type of oscillograph that is used depends on the frequency of the highest significant harmonics in the strain pulse or wave.

Additional instruments include balancing equipment for the strain gauge bridge circuits, calibrating equipment, and amplifiers, if required, to drive the oscillograph galvanometers.

THE STRAIN GAUGES

AN ELECTRIC strain gauge is a pickup device which can be attached to a member to which strain is to be applied, and which will produce a voltage or a change in a circuit parameter in proportion to the strain. Two types of strain gauges are in common use.

The Reluctance Strain Gauge. A typical reluctance strain gauge is attached to a member, such as a railroad rail, by means of two screws. Such a gauge consists of a laminated structure and coil which is attached to the member with

Essentially full text of a conference paper recommended by the AIEE Committee on Instruments and Measurements and presented at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951.

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one screw, and a laminated armature which is attached to the member by another screw. As the distance between the two screws changes due to the application of stress to the member, the air gap between the laminated structure and the armature changes, thus changing the inductance of the coil.

The measurement of strain is now a problem of measuring the inductance of the coil. This is done by making

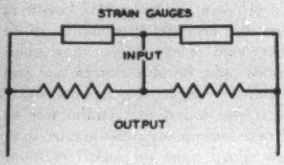

Figure 1. A common bridge circuit using strain gauges in two arms

the strain gauge one arm of an a-c bridge, and by exciting the bridge with alternating current and measuring the a-c output from the bridge. The bridge output is very nearly linear with respect to strain because the air gap variation is very small as compared with the total gap.

This strain gauge is operated at 2,000 cycles, and the output is rectified and filtered and used to drive an oscillograph galvanometer. This system is capable of accurately recording all strains within a frequency range of 0 to 500 cycles per second.

The reluctance strain gauge is satisfactory for use on heavy members, but it is too large and heavy for most aircraft parts. The two holes required for its attachment are not objectionable with large sections, although it would not be permissible to drill holes in most small sections.

The Resistance Strain Gauge. The resistance strain gauge consists of a small grid of fine resistance wire which is cemented directly to the member under test with a piece of thin paper in between for insulation.

When the member is strained, the strain at its surface is imparted to the wire. This elongation of resistance wire produces a change in its resistance because of two factors, (1) the change in cross section resulting from elongation, and (2) the change in resistance because of a peculiar relationship between specific resistance and strain that is possessed by some metals. With this type of gauge, strain is measured by measuring a resistance change.

Resistance strain gauges can be made very small so that localized strain in small areas, even as small as 1/8 inch in diameter, can be measured. Because the gauge is very light and because the sensitive element is close to the surface of the member, resistance strain gauges can be used on small members and thin sections.

The change of resistance of a resistance strain gauge is rather small. For example, a typical 120-ohm resistance strain gauge will show a resistance change of 0.087 ohm for a stress of 10,000 pounds per square inch in steel. This small change requires the use of amplifiers except for very low-frequency work, and it requires the exercise of great care to avoid temperature errors. Unless the operator is careful, he may be recording temperature variations instead of strain.

Resistance strain gauges are always used in bridge circuits, and one arm, two arms, or all four arms may be made up of gauges. Figure 1 shows a common arrangement in which two arms are gauges. This 2-arm arrangement is used often because effects of temperature on gauge resistance are balanced out, assuming, of course, that both gauges are subjected to the same temperature.

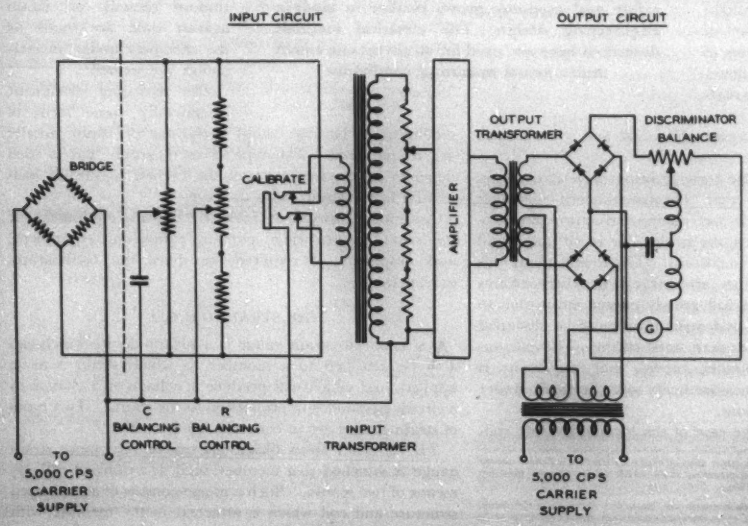

Figure 2. Typical strain gauge bridge and carrier amplifier with a phase-selective demodulator

The 2-arm arrangement shown in Figure 1 requires that either only one gauge be strained or that each gauge is strained in the opposite direction.

The input to the strain gauge bridge may be either alternating current or direct current, depending on the type of equipment used in the rest of the circuit. If an amplifier follows the gauge bridge, a-c excitation is usually employed because of the difficulty of stabilizing d-c amplifiers.

OUTPUT CIRCUITS

THE STRAIN gauge bridge shown in Figure 1 may be coupled directly to an oscillograph galvanometer for recording very low-frequency strains. In general, strain up to 50 cycles per second in frequency may be recorded in this manner, but the gauge output is not high enough to drive galvanometers with higher frequency response.

When it is necessary to record dynamic strain components higher than about 50 cycles per second in frequency, some form of amplification must be used to drive high-frequency oscillograph galvanometers. Several types of amplifiers are in common use.

A-C Amplifiers. The simplest form of amplifier that can be used with strain gauges is a wide-band resistance-capacitance-coupled amplifier. Amplifiers of this type can be built to handle frequencies as high as desired, although the low-frequency cutoff prevents the measurement of static strain. A typical strain gauge amplifier of this type has a frequency response curve well covering the frequency range of 2 to 6,000 cycles per second.

Carrier Excitation. Most strain investigations require the measurement of static as well as dynamic strain. To meet such requirements, it is customary to excite the strain gauge bridge with alternating current several times higher in frequency than the highest strain frequency. This excitation power is known as the carrier.

With carrier excitation, the strain gauge bridge output consists of the carrier which is amplitude-modulated by the strain encountered. The modulated carrier output of the strain gauge bridge is amplified by a resistance-capacitance-coupled amplifier. The amplifier output is demodulated to remove the carrier, and then used to drive the oscillograph galvanometer. A refinement of this system uses a phase-selective demodulator or discriminator circuit which supplies zero galvanometer current at zero strain, and the direction of galvanometer current depends on the direction of strain.

Figure 2 is a circuit diagram of a typical carrier amplifier with a phase-selective demodulator consisting of two full-wave bridge rectifiers. This amplifier is designed to operate with a 5,000-cycle carrier and to provide a frequency response of 0 to 1,500 cycles per second. A complete 12-channel carrier-type strain gauge amplifier unit and its associated power supply, all in a single case, employs an amplifier unit that uses 12 amplifiers of the type shown in Figure 2, and each amplifier is provided with strain gauge bridge-balancing controls. Calibrating equipment is built into this unit so that any channel can be calibrated in terms of strain per inch of deflection on the associated oscillograph. The power-supply unit supplies 5,000-cycle carrier power as well as regulated plate power for the amplifiers.

By using more sensitive galvanometers which would limit the system's frequency response to 500 cycles per second, these amplifiers can provide the following sensitivity: at least 1 centimeter of deflection on the record for each microinch of strain. With this sensitivity, the noise appears on the record as a maximum deflection of 1 millimeter.

D-C Amplifiers. Direct-coupled or d-c amplifiers are being used for the measurement of very high strain frequencies, up to 50 or 100 kc. For frequencies of this order, the carrier system is not satisfactory because of the higher carrier frequency that would be required and because of the difficulty in balancing the strain gauge bridge at high frequencies.

Figure 3. A 12-element electromagnetic oscillograph for aircraft use

Direct-coupled amplifiers with sufficient gain and power output are not impractical for this application, even in multielement units, although the elaborate power supply equipment required makes the system considerably more bulky and costly.

THE OSCILLOGRAPHS

THE FINAL portion of the dynamic strain measuring system is the oscillograph or recorder. For recording over the frequency range of 0 to 5,000 cycles, the electromagnetic oscillograph ordinarily is used. For strain recording this type of oscillograph is fitted with a continuous-drive chart system that drives the chart at uniform speed as long as recording is in process.

Several types of galvanometers are used with electromagnetic oscillographs for strain recording. For the frequency range of 0 to 50 cycles per second when amplifiers are not used, D'Arsonval galvanometers usually are used which are specially built for maximum frequency response by the use of very small coils and mirrors. Bifilar galvanometers are usually used when it is desired to record higher frequencies, up to a maximum of about 5,000 cycles.

Figure 3 shows a small 12-element oscillograph which uses 12 bifilar galvanometers especially designed for the

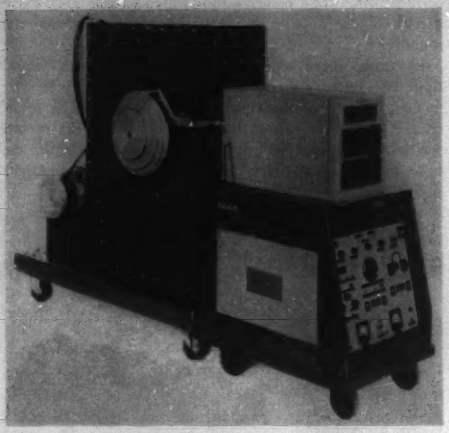

Figure 4. A 6-element oscillograph having a frequency response from 0 to 200,000 cycles per second

dynamic measurement of strains in aircraft structures.

For strain recording at very high frequencies, a 6-element recording cathode-ray oscillograph is shown in Figure 4. This illustration shows the oscillograph attached to a large drum-type record holder. Small continuous-drive record holders are also available for use with this oscillograph when longer records at lower speeds are required. In the oscillograph the record traces are made by brilliant spots of light which are images of the fluorescent spots on the screens of the six cathode-ray tubes. Using sensitive film which is especially sensitive to blue light, this oscillograph has a maximum writing speed of 5,000,000 inches per second.

The large magazine shown in Figure 4 employs a drum 3 feet in diameter and with a 6-inch face. The sensitized film or paper is attached to the face of the drum, and the drum is brought up to speed before the record is taken. The drum can be driven up to about 3,200 rpm to provide a record speed of 6,000 inches per second.

This oscillograph has a frequency response of 0 to 200,000 cycles. This frequency response, plus the high writing speed possibilities of 5 inches per microsecond, plus high possible record speed, make this type of oscillograph suitable for recording very fast strain transients. For strain recording it is used with direct-coupled amplifiers between the strain gauge bridges and the oscillograph deflection plates.

As we become more interested in higher and higher frequency phenomena, the instrumentation engineer will be called upon to develop the necessary equipment. As evidenced by past records he will undoubtedly be able to satisfy the needs as they arise.

A Carrier-Current Frequency-Shift System for Protection of Transformer Banks

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Using crystal-controlled frequency-shift techniques, this system provides fast operation with a high degree of reliablity. This discussion describes the design requirements and tells how they were met.

WHEN A SINGLE transmission line is fed from a transformer, it is economically desirable to omit the high-side circuit breaker. This necessitates transmitting a tripping signal to the remote circuit breaker in the event of a transformer fault as indicated by differential relays.[1] In the past, the available carrier-current systems have not provided the speed of operation or degree of reliability that could be obtained by using a high-side circuit breaker to protect the transformer banks.

The carrier-current system described here has been developed using crystal-controlled frequency-shift techniques to provide high-speed (2 cycles) transferred tripping with assurance against undesired tripping due to any combination of power failure, component failure, switching, or other influencing factors. Thus, a degree of reliability is provided which is comparable to the use of a high-side circuit breaker.

This frequency-shift system employs the principles of frequency modulation for the transmission of control impulses. As applied to transferred tripping, a blocking carrier is transmitted normally on one frequency and

Essentially full text of paper 51-153, "A New Carrier-Current Frequency-Shift System for Use with Differential Protection of Transformer Banks," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE North Eastern District Meeting, Syracuse, N. Y., May 2–4, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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shifted slightly to a tripping frequency for automatic circuit-breaker operation.

The basic application consists of a single narrow-band frequency-shift carrier-current channel operating on a frequency different from that used for the carrier pilot relaying. In the first application, however, the unusual importance of extreme reliability and simplified testing techniques resulted in the application of two paralleled carrier channels interlocked so that both must operate to cause tripping. Either channel may be tested by itself without causing tripping.

GENERAL OBJECTIVES

THE PRIMARY problem of reliability was approached in several ways. First, everything possible was done to reduce the chance of failure of each circuit either due to component failure or to external influence. Second, the circuits were arranged so that most failures would not cause tripping, and where this was impossible, circuits were arranged so that false tripping could not take place except in the extremely rare event of two failures occurring simultaneously.

In view of this, the following performance requirements were established:

1. The equipment should not cause tripping with extreme carrier-frequency disturbances such as caused by an arcing disconnect switch feeding a short section of bus or line. This condition should be met even with simultaneous failure of the blocking signal.
2. The equipment should trip upon transmission of proper signals even with extreme interference at the receiving end.
3. It should have the greatest possible freedom from the chance of false tripping from a stray signal even with the simultaneous failure of the blocking signal.
4. The over-all operating time should be very short to minimize the extent of the fault damage to the protected transformer.
5. The carrier-current equipment should operate from the station battery.
6. The equipment should operate properly with disturbances on the station battery such as are caused by dirty motor commutators, circuit-breaker operation, or battery charging. Tripping should not occur upon failure of the blocking signal with this disturbance on the d-c supply.
7. The number of tubes should be held to a minimum and long-life tubes used wherever possible.
8. The equipment should not cause tripping with the normal emission failure of any tube.
9. There should be some means of indicating at the receiving end the failure of received signal.
10. It should be possible to test the channel completely one part at a time, without depending upon co-ordination of the operators at the two ends to prevent accidental tripping.
11. Preferably equipment for transferred tripping should be independent from carrier-current equipment used for functions other than relaying so that maintenance interruptions can be held to the minimum number necessary for the transferred-trip channel itself.

Narrow-band frequency-shift equipment, such as was already in use for telemetering,[2] was chosen since it basically fulfilled the most difficult requirements and could be adapted rather easily to fulfill all others. It already had been established that because of the very narrow bandwidth and the noise balancing characteristics of the crystal-type frequency-shift telemeter equipment, greater distances could be covered and higher noise levels tolerated than with other types of channels used for telemetering.

Each of the requirements was met in a manner which can best be described in the following tabulation which corresponds to the tabulation of requirements.

1. Random noise, equally distributed over the bandwidth of the receiver, will cancel out in the discriminator.[3] To assure that noise will not cause tripping, the crystal filter circuit is unbalanced slightly by means of its balance capacitor. This causes the noise accepted by the receiver to predominate near the blocking frequency and produce a negative discriminator output. In addition, a rectifier and filter circuit in the discriminator output rectifies any fluctuation in the discriminator output and produces further negative blocking voltage. Upon application of the tripping frequency, a positive output operates the relay tube and contacts of the associated relay close the trip circuit.
2. The extremely narrow bandwidth limits the noise energy accepted and permits the desired signal to override it and perform its function.
3. With the use of two channels, the chances of interfering signals occurring at the two precise frequencies necessary at exactly the same time are very remote indeed.
4. Tests show the over-all operating time of the carrier-current equipment to be less than 2 cycles, not including time of any auxiliary relays.
5. Both transmitter and receiver operate directly from a 125-volt d-c station battery, using tubes with heaters in series.
6. Power supply filters are included in both transmitters and receivers to prevent interference from the power source. The transmitter and receiver operate properly with a 2-second drop to 105 volts d-c and with a rise in voltage to 140 volts d-c. However, continued operation at voltages more than ± 5 per cent away from normal will shorten tube life.
7. The transmitter uses only three tubes and the d-c-operated receiver uses four. Tubes designed for long life are used and are operated very conservatively.
8. In the transmitter, the frequency is shifted from one crystal-controlled value to another by means of a reactance tube. Since the most likely failure (loss of emission) of this tube would result in failure to shift frequency, the tube is normally inoperative and is caused to operate and shift frequency for the tripping function. Any other failure is highly unlikely and the simultaneous failure of the tubes in two transmitters, when used, can be disregarded completely. The receiver trip relay normally is dropped out and usual tube failures will not cause current

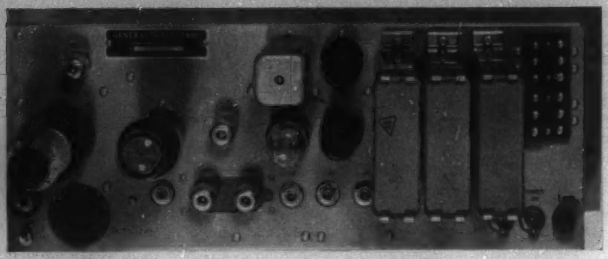

Figure 1. The crystal-controlled transmitter used for sending the tripping signals

to be drawn. A grid short circuit could cause one tube to pick up the corresponding relay; however, again, the simultaneous failure of relay tubes in two receivers can be disregarded. An alarm is arranged to operate upon closing of either receiver relay so that any possible difficulty can be eliminated immediately.

9. The receiver cathode current of a radio-frequency amplifier tube is fed to an external indicating meter. This serves as an indication of received signal because of automatic volume control action. Also, the blocking frequency is used to operate a signal-alarm relay whose contacts will close an alarm on failure of received blocking signal. This same relay will drop out on failure of supply voltage or on failure of any receiver tube filament. A very complete check thereby is provided on all parts of the channel at all times.

10. With two separate channels, a tripping signal can be sent, first on one and then on the other channel by means of a switch arranged so that both can never be sent at once.

11. Fundamentally, the frequency-shift equipment is based on the use of independent equipment for each function.

DESCRIPTION OF EQUIPMENT

Figure 1 shows the transmitter and Figure 2 the receiver of most recent design, both of which are designed for direct operation from 125 or 250 volts d-c with external resistor. Figure 3 shows a block diagram of the circuits of the two units. The output power of the transmitter is 1.5 watts which is sufficient for all usual applications. The units are designed for operation with appropriate crystals at any frequency between 70 and 200 kc.

The receiver provides freedom from effects of random noise and transients, first by utilizing a crystal filter to accept energy in only the narrowest band possible and still pass the necessary desired signals. (It is because of the high Q of this circuit, of the crystal discriminator, and of the crystal oscillator in the transmitter that a time equal to 2 cycles is needed to transmit the tripping signal. In other words, these circuits have a high inertia and a definite time is required to change the frequency and thus change from negative blocking to positive tripping output from the discriminator.) Second, an amplitude limiter rejects a large part of the noise effect as is well known from the use of such a circuit in other frequency-modulation receivers.

A third noise reduction is effected by the balancing effect of the crystal discriminator. Since the blocking frequency is transmitted continuously during fault or test intervals, a negative voltage from the discriminator adds to the fixed bias on the tripping relay tube so that the relay is very effectively prevented from operating. To prevent incorrect operation in the event of failure of blocking signal several additional steps are taken. A typical discriminator characteristic is shown in Figure 4. If the random noise and transients tend to have frequency components falling both in the region marked *A* and in the region marked *B*, the net effect over any short period of time will be to cancel out. To assure that the trip relay will not pick up upon the simultaneous failure of blocking signal and occurrence of a disturbance such as caused by the opening of a bus disconnect, an adjustment of the crystal filter was found which causes the effect of the transients to fall more largely in region *B* and therefore will hold the trip relay in the de-energized position. To further distinguish between signal and noise, a rectifier and filter are placed between the discriminator output and relay tube grid. This circuit rectifies variations in dis-

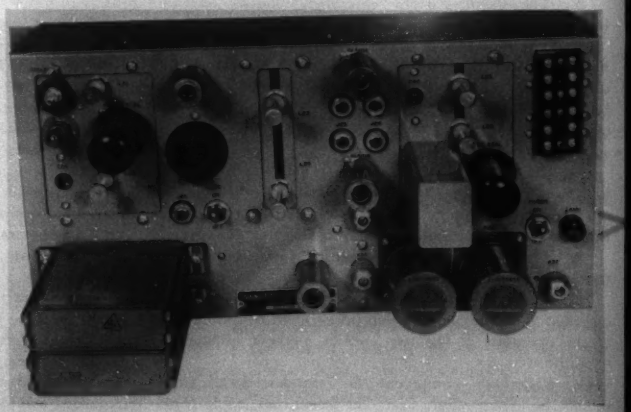

Figure 2. The carrier-current receiver. This unit is also crystal-controlled

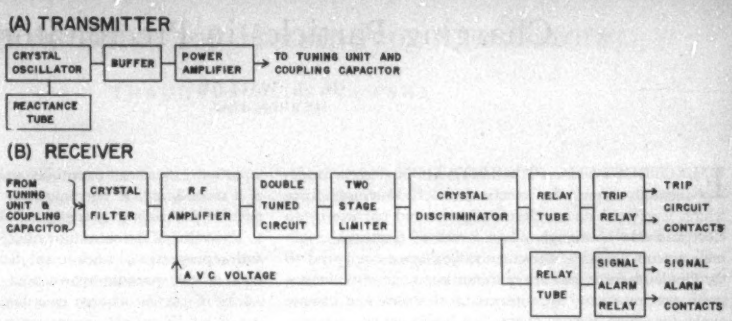

Figure 3. Block diagram of the receiver and transmitter. Operating range is between 70 and 200 kc

criminator output, such as produced by noise, and produces additional negative voltage on the grid of the trip relay tube. When the desired signal is present, the noise variations are suppressed by the limiter so this latter circuit produces its desirable effect only in the event of carrier failure.

It may seem that safety factors have been added, one on top of another, even to an unnecessary degree. However, the cost of all of the features is small compared to the cost of the protected equipment. During operating tests of this equipment on a 132-kv line, it was most gratifying to observe proper operation of the equipment even with the blocking signal absent and with so much interfering noise as to ignite continuously a neon bulb connected in the receiver input as a protective device.

These tests were made with noise generated by opening a bus disconnect a small amount so that an arc was formed by the charging current to several hundred feet of bus structure, which, of course, had no connected loads. This arc was "tuned" by opening until maximum interfering current was read on some audio tone transferred to tripping equipment of older design. Observation of current in the tripping relays of the frequency-shift equipment showed zero current on a meter with 100 microamperes' full-scale deflection with blocking frequency transmitted or with the transmitter off. When the tripping frequency was transmitted the relay current held steady at the normal operating level.

During a staged arcing fault test an observation of relay current with transmitter off was made and the results were the same; that is, the fault did not produce relay current. Other tests in the past have indicated that this condition is not as severe as the arcing bus disconnect, however.

Much thought has been given to the choice of using either a single channel or two channels to perform the operation. In the event that an extraneous signal somehow appeared at the exact tripping frequency at the same time as failure of transmitted signal because of a fuse blowing in the power source, tube burnout, and so forth, the use of one channel could result in false tripping. As can be seen, this combination of events is quite a remote possibility and may be accepted as a calculated risk. A time-delay relay could be used to open the trip circuit at some fixed time after the signal alarm relay operates, indicating failure of received signal. This would reduce the possible time during which the aforementioned calculated risk could occur. The same feature can also be accomplished by instructing an operator to open the trip circuit manually upon receipt of a carrier failure indication.

A single channel must be tested by first opening the trip circuit at the receiving end and then transmitting a tripping signal. This allows for a human error in co-ordinating the test and results in divided responsibility in the event of a failure in co-ordination. With two channels a tripping signal can be transmitted first on one and then the other with a switch so arranged that transmission of a simultaneous tripping signal on both channels during testing is impossible.

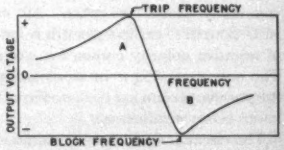

Figure 4. Characteristic of the receiver discriminator

Two channels can be spaced as close as 0.5 per cent in frequency so that common single-frequency line-tuning units, traps, and coupling capacitors may be used. In this way two channels are nearly as easy to fit into a crowded frequency spectrum as one. The use of two channels requires only the addition of a transmitter and receiver unit and small changes in the auxiliary test and tripping circuits. With two channels switches can be provided for operation on one channel during maintenance work on the other channel.

As can be seen, the choice between single- and double-channel operation depends upon the seriousness of a false circuit-breaker operation and upon whether the additional cost is justified to secure the ultimate in security.

REFERENCES

1. Carrier-Current Differential Protection for Transformer Banks, **T. A. Cramer.** *Electrical Engineering* (AIEE *Transactions*), volume 62, August 1943, pages 545–8.

2. Characteristics of New Carrier-Current Equipment for Telemetering and Load Control, **R. W. Beckwith.** AIEE *Transactions*, volume 67, part II, 1948, pages 1649–52.

3. Frequency Response Circuits, **R. W. Beckwith.** United States *Patent 2,46,7856.*

Charging Particles in Precipitators

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ELECTROSTATIC PRECIPITATION derives fundamentally from the mechanical or Coulomb force which is exerted on an electrically charged particle in an electric field. Although other forces of electrical origin may act on particles, these are insignificant compared to the Coulomb force and are of minor importance in electrostatic precipitation. In contrast to electrons and atomic nuclei for which electric charge is a fundamental property, the smoke, fume, fog, and dust particles of technology may be uncharged entirely or charged only to a low degree.

Electrical activity is associated with so many physical and chemical phenomena that the problem is choosing the best method of charging particles rather than searching for a single available method. The unipolar corona discharge is by far the best particle-charging means, not only because it is effective but also because it is practical and easy to control under industrial field conditions.

In an electric precipitator the corona discharge is established between a set of active electrodes, usually in the form of wires or points, and a set of passive electrodes, commonly plates or tubes. All experience, beginning with Cottrell's[1] earliest work, has indicated the superiority of negative polarity corona for electrostatic precipitation. The only exception is in air-cleaning precipitators, where the positive corona has been preferred because of its possibly lower ozone production.

The essential features of the corona discharge for electrostatic precipitation purposes are: (1) a highly active but restricted region close to the discharge electrode which contains both positive and negative ions; and (2) a passive region throughout the remainder of the discharge space which contains a dense concentration of unipolar gas ions generated by electron ionization of gas molecules in the active region of the discharge. For the majority of cases the corona ion density ranges between 10^8 and 10^9 ions per cubic centimeter, with corresponding electric field strengths of from 1 to 10 kv per centimeter.

Theoretical calculations of particle charging necessarily are based on a number of simplifying but not invalidating assumptions, such as that of spherical particles. Two distinct charging mechanisms are active: (1) bombardment of the particles by gas ions moving under the force of the electric field; and (2) thermal diffusion of ions to the particles. Charging by the ion bombardment process is governed by the particle radius a, the field strength E_0, the ion density N_0, and the ion mobility K. For a conducting particle the charge n (electronic charges) at a time t is given by

$$n=\frac{3E_0a^2}{e}\,\frac{t}{t+\frac{1}{\pi N_0eK}} \qquad (1)$$

Under ordinary conditions the time-dependent factor of equation 1 becomes essentially unity in a few hundredths of a second, a time corresponding to only a few inches of particle path in the precipitator charging field.

The value of the saturation charge n_s obviously is $3E_0a^2/e$, and is proportional both to the field E_0 and to the surface area of the particle represented by a^2. Representative values of particle charge calculated from equation 1 for, say, $E_0=6$ kv per centimeter are $n_s=10^2$ electronic charges for a 1-micron diameter particle, 10^4 for a 10-micron particle, and 10^6 for a 100-micron particle. The saturation charge in each case is determined by the balance between the repulsive field of the charge accumulated on the particle and the driving force of the external or corona field.

Charging by the ion-diffusion process may be shown to follow the approximate equation

$$n=\frac{akT}{e^2}\ln\left(1+\frac{\pi aCN_0e^2}{kT}t\right) \qquad (2)$$

where the symbols not previously defined are the Boltzmann constant k, the absolute temperature T, and the kinetic theory rms random velocity of the ions C. For the usual range of precipitator conditions, the value of n calculated by equation 2 is much smaller than that given by equation 1 for all except particles of less than a few tenths micron diameter. From this result it appears that the diffusion-charging process is unimportant for all except submicroscopic particles.

Experimental verification of the particle-charging equations on a laboratory scale has been obtained by a number of investigators during the past 25 years. Field studies of particle charging are more difficult because of lack of control of the experimental factors and the difficulty of obtaining representative samples, but results appear to be in general agreement with the theory.

Conditions which interfere with normal precipitator operation by causing the particle charge to be abnormally low are: (1) space-charge suppression of corona current which tends to occur with fine fumes; (2) back corona, or the localized discharge which occurs at the collecting electrode surface caused by very high dust resistivity; and (3) erosion or windage loss of particles from the collecting electrodes which sometimes occurs under high gas velocity or highly turbulent gas flow conditions. Experimental procedures make it possible to detect these conditions in the field and to indicate the necessary corrections.

REFERENCE

1. Art of Separating Suspended Particles from Gaseous Bodies, F. G. Cottrell. United States *Patent* 895,729, August 11, 1908.

Digest of paper 51-200, "Particle Charging in Electrostatic Precipitation," recommended by the AIEE Committee on Electronics and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25-29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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A Servo Drive for Heterodyne Oscillators

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HETERODYNE oscillators are used frequently in a measuring system in which the oscillator is swept over its frequency range by means of a motor while the characteristic being measured is recorded on a strip of perforated chart paper linked to the frequency control through a toothed chart drive mechanism. The linkage may be purely mechanical or it may be obtained by the use of two synchronous motors, one driving the frequency control of the oscillator and the other the chart advance mechanism on the recorder. One of the advantages of the latter arrangement is that the recording may take place far from the oscillator—say, at the end of a long cable whose transmission is being measured—provided the motors are driven from a power source of accurate frequency.

The present article describes an oscillator driving mechanism which produces a constant time rate of progression of the oscillator frequency independently of the shape of its calibration curve. With such an arrangement, if the synchronous motor at the recording end is driven from a source of constant frequency, the frequency scale is linear and therefore it may be preprinted on the recording paper.

Another use for such an oscillator drive, and incidentally the one for which it was developed, is in measurements where the integral

$$\int_{t_0}^{t} F(f)\,df$$

of the measured characteristic, instead of the characteristic itself, is desired. In such cases $F(f)$ is integrated with respect to time by electronic means; and, since $f = Kt$, when the substitution is made in the above integral

$$\int_{t_0}^{t} F(f)\,df = K\int_{t_0}^{t} F(f)\,dt$$

It is seen that the time integral, when multiplied by a known constant of the system, furnishes the desired frequency integral.

In order to obtain the constant time rate of progression of frequency, the oscillator output is fed into a measuring detector (Figure 1) which determines the times $t_0, t_1, t_2 \ldots$ at which the oscillator frequency is respectively $f_0, f_1, f_2 \ldots$, the frequencies f_n being separated by a constant frequency interval $\Delta f = f_{n+1} - f_n$. A pacing circuit furnishes a slowly rising, fast-dropping saw-tooth-shaped voltage output derived from an accurate frequency standard. The saw-tooth wave frequency being constant, the times t_0', t_1', t_2', ... at which the slowly rising portion of the wave begins are separated by equal intervals Δt. The values of Δf and Δt are selected so that the ratio $\Delta f/\Delta t$ equals the desired average rate of progression of frequency with time.

A comparison circuit measures the time intervals $t_n - t_n'$ by sampling the raising portion of the pacing wave. The result of the measurement appears as a control voltage across the grid of a variable gain stage of a power amplifier,

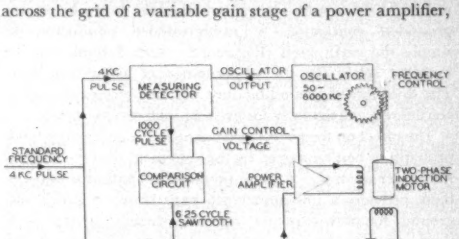

Figure 1. Block diagram of the servo drive for the oscillator

which amplifies a 60-cycle signal applied to the motor driving the frequency control of the oscillator.

If the frequency is higher than $t\Delta f/\Delta t$ the effect will be to decrease $t_n - t_n'$. The motor voltage will decrease and the motor will slow up. If the frequency is lower, $t_n - t_n'$ will increase and the motor will accelerate until an equilibrium is reached.

Thus deviations in frequency from the required value produce a regulating voltage change restoring dynamic equilibrium. Whenever the scale spread of the oscillator is larger than average, the motor has to run faster and the equilibrium point is displaced upwards. Where the scale spread is less than the average the equilibrium point is displaced downwards. The constants of the system are selected so that a 10 per cent variation in the scale spread can be handled. In order to insure that the cardinal values of frequency coincide with the major divisions on the frequency scale, the motor driving the paper is energized through a relay which, in turn, is tripped by a tuned circuit by the oscillator output. The paper drive is preset to a suitable position before the oscillator drive is started. Once the record is completed, the only editing needed is the counting and labeling of the major divisions on the recording chart.

The accuracy of the oscillator as checked by a monitoring oscilloscope is about ±1 kc over a frequency range of 0.05 to 8 megacycles. This is higher than the reproducibility by manual setting of the oscillator scale. Speeds of 10, 12.5, and 50 kc per second have been used successfully.

Digest of paper 51-218, "A Servo Drive for Heterodyne Oscillators," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25-29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Grounding Banks for Balancing Feeder Voltages

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DISTRIBUTION engineers, seeking means to provide a better balance of neutral voltage on 3-phase feeders, have suggested the use of grounding banks at one or more points along the feeder. The term 'grounding bank' is used here to mean a Y-delta transformer bank, the Y side tapped from the feeder with the Y neutral connected to the system neutral, whether the latter be an ungrounded conductor, a multigrounded conductor, or simply the earth itself (Figure 1). Such a bank may be installed solely for the performance of grounding duty. The dual role of grounding duty and load service should be considered, particularly for existing load-serving banks.

The effect on feeder voltage balance of a grounding bank probably is best expressed by the statement that it stabilizes the feeder neutral. A more precise explanation is that the bank provides a low-impedance path between feeder and ground for zero-sequence current, thereby acting as a short circuit on zero-sequence voltage. It should be apparent, then, that a grounding bank cannot aid in balancing line voltages in which there are no zero-sequence components, and can provide no benefit to feeder loads connected through the step-down combinations not having a neutral connection to the feeder, for example, delta-delta, delta-Y, Y-Y-ungrounded, and open delta. However, the balance of feeder neutral voltages can be much improved by a reduction of the zero-sequence component with benefit to the so-called phase-to-neutral loads; that is, loads supplied through the transformer connections of single-phase-to-neutral, Y-Y-grounded, and open-Y. It should be noted that no improvement is achieved for the load of a Y-delta connection, whether grounded or not, including the secondary load, if any, of the grounding bank itself.

For a bank to be installed to do grounding duty only, the questions to be settled are (1) the location of the feeder, (2) the size and impedance of the bank, (3) the effectiveness of the bank in reducing zero-sequence voltage, and (4) the protection required.

For a load-serving bank, grounding the Y neutral to impose grounding duty on the bank is a departure from the usual practice of leaving the Y neutral isolated to avoid grounding duty. The location, size, and impedance of the transformers are already fixed, and the problem becomes one of determining whether grounding is feasible; that is, whether the bank is capable of handling a normal ground current in addition to its load. The determination to be made concerns (1) ground current that will flow in the bank, (2) effectiveness, and (3) protection.

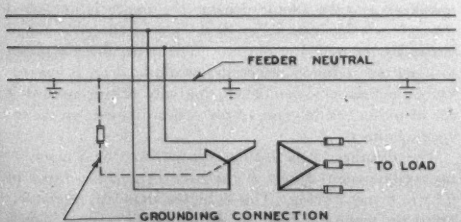

Figure 1. Y-delta transformer bank tapped from feeder

A bank to be initially installed should be located at a point where voltage conditions are worst, or where stabilizing the neutral is important, such as a branch point.

The grounding duty or the bank size and impedance may be determined from the expression

$$\frac{k}{p} = \left| \frac{1}{\frac{U_T}{U_F} + \frac{Z_{T/I}}{Z_{0/I}}} \right| \tag{1}$$

where k is the per-unit ground current in the bank; p is the per-unit feeder unbalance; U_T and U_F are the bank and feeder kilovolt-ampere ratings, respectively; and $Z_{T/I}$ and $Z_{0/I}$ are the complex per-unit values of the bank impedance and feeder zero-sequence impedance at the bank location, respectively. Per-unit values are on transformer base for transformer quantities and feeder base for feeder quantities. The value of p is obtained from

$$p = \left| \frac{V_{N/I}}{Z_{0/I}} \right| \tag{2}$$

where $V_{N/I}$ is the per-unit floating neutral voltage of the feeder at the grounding bank location.

For the bank that does grounding duty only, all values in equation 1 are known except bank size and impedance, and a table of minimum bank kilovolt-amperes required versus several transformer impedance values may be made as an aid to selection. Where load service must also be considered, the grounding current is evaluated from equation 1 and compared to the permissible duty to determine the feasibility of grounding. The effectiveness of the banks expressed as a per-unit reduction of zero-sequence voltage is

$$e = \frac{k}{p} \frac{U_T}{U_F} \tag{3}$$

provided k/p is calculated from equation 1 and is not merely the ratio of two independent estimates.

The protection of the bank against excessive ground current is accomplished by fusing the connection between Y neutral and system neutral. The worst that can happen when a fuse blows is that the bank becomes ungrounded.

Digest of paper 51-148, "An Analysis of Grounding Banks to Balance Distribution Feeder Voltages," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Southern District Meeting, Miami Beach, Fla., April 11-13, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Effect of Voltage Dip Duration on Cyclic Light Flicker

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Evidence is presented that the duration of voltage dips, as well as their frequency, is an important factor in flicker visibility. The tests include both incandescent and fluorescent lamps.

"FLICKER," as considered in this article, is the sensation of change in the illumination intensity or in the brightness of stationary objects. Only one phase of the flicker problem will be discussed, namely, the cyclic flicker due to the fluctuations of voltage at the terminals of the electric lights which produce the illumination. The performance of 100-watt incandescent and 15-watt "white" fluorescent lamps in particular will be covered.

It is customary to treat flicker in two general groups: cyclic and noncyclic. Cyclic flicker is caused by periodic voltage fluctuations such as may be produced by the operation of a seam welder, while noncyclic flicker is due to occasional voltage dips, as may be caused by the random operation of a spot welder. A comprehensive report[1] prepared by the Electrical Testing Laboratories in 1937 summarized the information available at that time on all types of flicker. With respect to cyclic flicker, which is the primary subject of this article, the 1937 report was confined apparently to symmetrical forms of voltage pulsation (Figure 1). Most of the data were obtained with sinusoidally pulsating voltage; some were rectangular in form, that is, both the dip and the recovery of voltage were abrupt. Saw tooth and cusped waveforms also were used in a few instances, but none of the investigations were concerned with the effect of the dip duration on the perceptibility of flicker.

As the flicker produced by nonuniform voltage fluctuations is of practical importance, particularly in problems associated with welder supply, the effect of the duration of the voltage dip on the perceptibility of cyclic flicker was made the subject of a systematic study and the results are given here. Figure 1*B* illustrates the type of voltage change which was studied and the table outlines the range of the investigation. The tests were made in 1939.

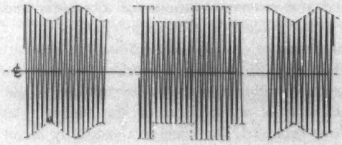
RANGE OF INVESTIGATIONS

THE FLICKER produced by 100-watt incandescent lamps was observed under dips of 1/2, 1, 2, 5, and 10 cycles' duration. In each series, the recurrence of the dips was varied between 0.033 second (in some cases) and 10 seconds, which corresponded to a frequency of voltage fluctuations between 30 per second (in some cases) and 1/10 per second. The voltage changes were produced abruptly. Studies on fluorescent flicker were limited to dips of 1 and 5 cycles.

Flicker perceptibility varies considerably among apparently normal individuals and it is also greatly affected by the degree of intentness or casualness of the observation. In addition, the wattage of the lamps used, the level of the illumination, and a great many other factors influence the visibility of flicker. An independent study of all of these factors was not necessary as the Electrical Testing Laboratories report deals adequately with them. The effect of individual variations and the intentness of observation, however, were taken into consideration by using a large number of observers and by segregating the observations into two general categories: intent and casual.

During intent observations the initiation of each flicker condition was announced and the observers were asked to

A. TYPES OF ISOCHRONIC VOLTAGE FLUCTUATION



B. TYPE OF FLUCTUATION INVESTIGATED

RANGE OF TESTS

	100 WATT INCANDESCENT	15 WATT FLUORESCENT	100 W. INCAND. WITH D.C.
DURATION OF DIP IN CYCLES t_{DIP}	1/2, 1, 2, 5, 10	1, 5	2, 5
FLICKER FREQUENCY MIN.	.1/SEC.	.1	.1/SEC.
FLICKER FREQUENCY MAX.	30/SEC.	30	15/SEC.
NUMBER OF OBSERVERS	300	8	13
" " OBSERVATIONS	12,000+	200	400
INTENT OBSERVATIONS	✓	✓	✓
CASUAL "	✓	—	—

Figure 1. Type and range of voltage changes investigated

Essentially full text of paper 51-165, "Effect of the Duration of Voltage Dip on Cyclic Light Flicker," recommended by the AIEE Committee on Electric Welding and approved by the AIEE Technical Program Committee for presentation at the AIEE Great Lakes District Meeting, Madison, Wis., May 17–19, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Figure 2. Arrangement of lamps and observers during tests

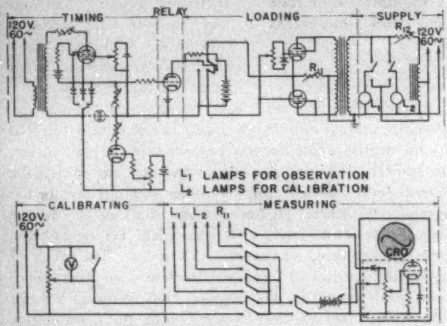

Figure 3. Electronic circuit for producing the flicker

view the objects best suited individually for the detection of flicker. At the threshold between perceptible and nonvisible flicker, the voltage changes sometimes were impressed and removed without the observers' knowledge and they were asked to call these changes.

In the series of casual observations the observers were engaged in some work such as reading, writing, computations, or conversation and they were unaware of the nature and the time of application of the flicker. After the flicker was removed, the observers voted by secret ballot as to whether the flicker was perceptible and, if so, whether it was considered objectionable.

Figure 2 shows the general arrangement of the six Illuminating Engineering Society luminaires, each with one 100-watt inside-frosted Mazda lamp, arranged on a table around which the observers were seated. The series of tests for the study of fluorescent flicker was made with one 15-watt white fluorescent lamp with a reactive ballast. Surface illumination at the table varied between 15 and 40 foot-candles during the study of incandescent flicker, while fluorescent flicker was studied under a surface illumination of approximately 16 foot-candles.

Recurrent voltage dips were produced abruptly at the lights by means of electronic timing and control equipment (Figure 3). A vacuum-tube loading circuit, connected in parallel with the lamps, applied additional load on the supply circuit at intervals determined by the operation of the timing circuit. This additional load caused an incremental voltage drop in the resistor R_{12} connected in series with the lamps, thus producing a dip at the lamps. Magnitude, duration, and frequency of the dips were measured by means of a cathode-ray oscilloscope with a 9-inch screen. In order to measure the magnitude of the dip, a biasing battery was connected in series with the amplifier input circuit; thus only the peaks of the voltage waves appeared on the screen and the oscilloscope functioned as a differential voltmeter of high sensitivity. The duration of the dip was noted from the number of halfway peaks appearing on the screen. Dips were initiated near the zero of the supply voltage wave. Figure 4 shows a 1.5-volt rms voltage dip lasting 2 cycles.

100-WATT INCANDESCENT LIGHTS

A SAMPLE OF the results is given in Figure 5, which pertains to the perceptibility of flicker under voltage dips of 5-cycle duration under intent and casual observation. Each test condition imposed on the observers is represented by a block, the width of which indicates the size of the observer group. The blocks are divided into an upper (shaded) and lower (unshaded) part in the same proportion as the ratio between affirmative (flicker) and negative (no flicker) votes. Where the flicker was observed by all observers, a totally shaded block is used, while a blank block indicates that none of the observers noticed the flicker. The curves drawn on the figure represent the average of response. The figure illustrates pictorially the variation in the flicker sensitivity of observers and the fact that in investigations of this sort scientific accuracy cannot be expected. A comparison of the two types of observation brings out the appreciable decrease in the perceptibility of flicker when engaged in some activity requiring a measure of concentration. The reduced consistency of response is largely due to different degrees of concentration, and, as is to be expected, the range of response becomes even wider when voting on the objectionableness of flicker. Because of the fact that the observers were acquainted with the nature of the problem, their opinion was probably biased in the direction of considering relatively small variations as objectionable; thus, while the curves indicate trends, the objection thresholds shown may be lower than experience in service would indicate.

Figure 6 is a summary of the results obtained with 100-watt incandescent lamps as illuminants. Each group of curves represents a single dip duration and the three curves in each group are the average thresholds of perception for

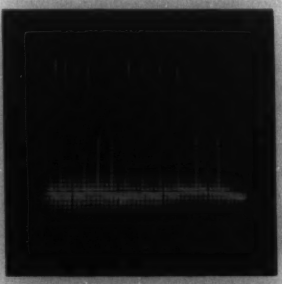

Figure 4. Typical oscillograph pattern of the voltage dips

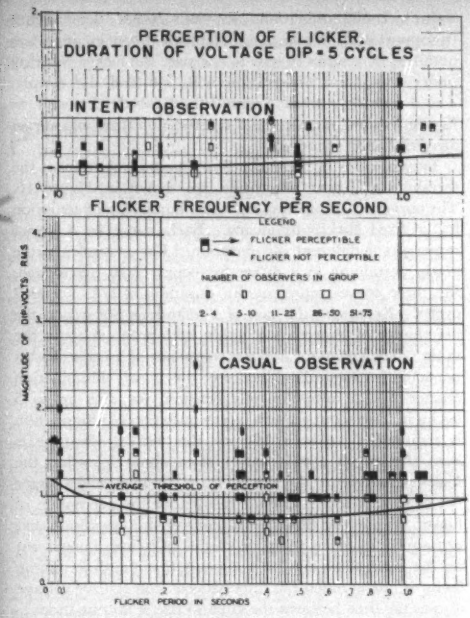

Figure 5. Flicker observations for 5-cycle voltage dips

intent and casual observations and the average threshold of objection. Under intent observation, flicker is most perceptible when the voltage dip lasts 2 to 5 cycles, at all flicker frequencies investigated. The spread between the threshold curves is relatively smaller under casual observation, but the general trend is the same as for intent viewing. It is significant that on the average the observers considered the flicker objectionable when the voltage was only slightly above the casual threshold.

The points marked with X represent symmetrical pulsations, that is, equal periods of dip and normal voltage. A plot of these points as a function of the flicker frequency (Figure 7) is the type of flicker characteristic heretofore available in the literature. For comparison, data obtained by Lindberg[1] on the most sensitive 10 per cent of his observers and tests reported by Weise[2] also are shown.

15-WATT FLUORESCENT LAMPS

INTENT OBSERVATIONS only were made at dips of 1 and 5 cycles and the results are shown on Figure 7. The difference between the performance of incandescent and fluorescent lamps is due to fundamental differences in the performance of these illuminants.

1. The change of illumination of a fluorescent lamp under a sustained change of voltage is less than one-half that of an incandescent lamp (1.2 per cent per volt for the fluorescent, and 2.7 per cent per volt for the incandescent lamp).

2. Fluorescent lamps respond much more quickly to the change of voltage. The illumination of incandescent lamps changes slowly due to the heat inertia of filament; fluorescent lamps have no similar heat inertia and the slight lag of illumination change is due to the phosphorescent "afterglow" of the coating materials of the tube.

These two factors affect the flicker performance in opposite directions. If the voltage dip lasts for a sufficient length of time so that the filament of the incandescent lamp can attain its new thermal equilibrium, the net change of illumination of the incandescent lamp will be more than that of the fluorescent lamp for the same voltage change. On the other hand, under rapid fluctuations of voltage the incandescent lamp will attain only a fraction of its total illumination change, consequently the in-

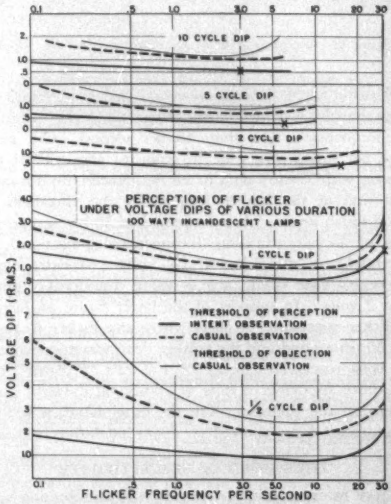

Figure 6. Flicker perception with dips of various duration

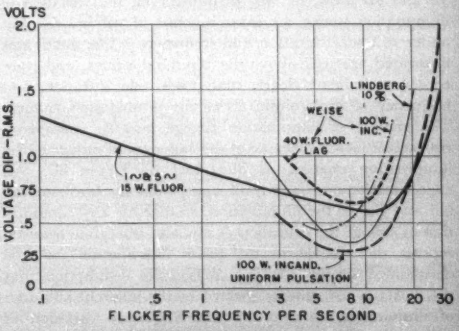

Figure 7. Comparison of fluorescent and incandescent lamps

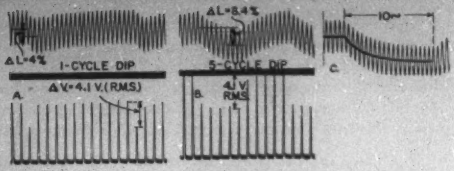

Figure 8. Illumination pulsations. Upper curves show illumination, lower curves of *A* and *B* show the voltage dips

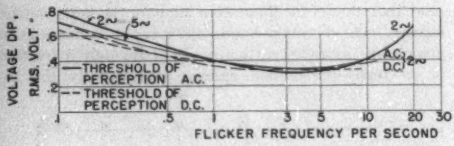

Figure 9. Comparison of flicker with a-c and d-c supplies

candescent lamp may produce less flicker. Weise's data show that the flicker of incandescent lamps is greater when the frequency is less than 15 per second. Our studies were not sufficiently wide in scope to allow direct comparison with Weise's data at all frequencies but it is significant that at the higher frequencies the threshold was found much lower. At a frequency of 30 per second with dips of 1-cycle duration (symmetrical pulsations), the threshold was established at $1^1/_2$ volts. An extrapolation of Weise's data would give a value considerably greater than 2 volts. In support of the lower figure an instance of flicker complaint is cited where the flicker frequency was 30 per second and the voltage drop was approximately 2.5 volts rms. The flicker of 100-watt "Tulamp" units was quite annoying in spite of additional daylight illumination on the premises. On the other hand, a 100-watt incandescent lamp showed no apparent flicker.

THRESHOLD OF PERCEPTIBILITY

IT MAY BE interesting to see how the illumination varies at the threshold of perception under the different conditions of flicker frequency and dip duration. Figures 8*A* and 8*B* show, by way of illustration, the variation of illumination under the same amount of voltage dip but under different duration and frequency. The conditions illustrated are well above the threshold values, and were chosen to indicate clearly that magnitude, duration, and frequency of dips jointly affect the illumination change. The analysis of illumination change may be made with reasonable facility because of the exponential nature of the illumination change, as illustrated by Figure 8*C*. An exponential curve is a good approximation for both the fall and rise of the illumination, so that for any combination of voltage dip, duration of dip, and total time between repeats the change in the mean illumination may be determined simply. It is a reasonable assumption that the flicker is not sensibly affected by the inherent pulsation of illumination due to the line frequency variation of voltage but is the result of the much slower change in the mean level of illumination. Previous studies offer evidence in support and, in addition, independent confirmation was obtained by a series of tests to compare the flicker visibility under the intent observation with a-c and d-c supply. The d-c tests were made with 2- and 5-cycle dips and, as Figure 9 shows, the a-c and d-c perception threshold curves are practically identical.

Typical cases of the mean illumination pulsation at the threshold of intent perception are shown in Figure 10. The curves are grouped to show the illumination fluctuation for a fixed flicker frequency. Each curve in a group represents a different dip duration. For example, in the group pertaining to a flicker frequency of 20 per second, the three curves represent dip durations of 1/2, 1, and 2 cycles. Except for the case of 3 pulsations per second the net change of illumination within each group is about the same. The group for a flicker frequency of 3 per second is particularly interesting because the mean illumination change is still approximately constant for dips up to 5 cycles in length but a much larger pulsation of illumination is required to make a 10-cycle dip visible. It appears then that if the dip is longer than about 5 cycles, the flicker sensitivity of the eye begins to diminish and a larger net change of illumination is needed for the perception of flicker. That the flicker sensitivity of the eye diminishes at frequencies lower than 5 cycles is, of course, known but on the basis of Figure 10 it appears that the determining factor is not so much the time between consecutive voltage dips as the time between the fall and rise of illumination.

As a rough first approximation, therefore, it may be assumed that at a fixed frequency and for the same type of illuminant, voltage dips of different duration will produce the same flicker sensation, provided the fluctuations of the mean illumination are the same, and provided that the dip is not longer than 5 cycles.

Instead of the total net change of illumination, the fundamental harmonic component of the curve representing the fluctuations of mean illumination has been considered, particularly in Europe, as the determining factor in flicker perceptibility. This approach is employed primarily for the evaluation of the inherent flicker of different types of electric illuminants due to the alternations

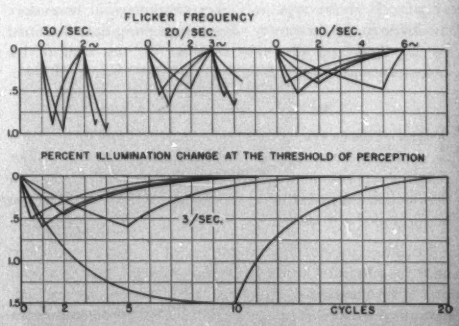

Figure 10. Illumination change at threshold of perception

of line voltage at line frequency[3–5] but it also has been applied to the comparison of incandescent and fluorescent flicker due to low frequency voltage variations.[6]

FREQUENCY-CHANGER WELDER FLICKER

Published cyclic flicker studies, including the present one, are confined to sustained pulsations. Reciprocating compressors, conventional seam welders, and high-speed automatic spot welders are typical loads to which the available data would apply. Frequency-changer welders[7,8] developed in the last few years also produce cyclic line voltage variations, but in spot welding applications of the system the voltage pulsates only briefly, each time a spot is welded. The response of the nervous system to such short-lived pulsations may not be the same as the reaction to a sustained flicker of the same frequency.

While not strictly a part of these studies, the increasing importance of frequency-changer welders makes it pertinent to discuss briefly the observations made in one particular application of a 3-phase welder supplied from a 3-phase 4-wire 120/208-volt network system. The welder current in one of the lines is shown on the top oscillogram of Figure 11. The voltage oscillogram in the center of the figure was taken at the light and power distribution panel while the bottom oscillogram shows the voltage at the point of power service to the premises. Because of the distance between the two points, the dip at the service is appreciably lower. Flicker voltage was measured from line to neutral (nominal voltage: 120 volts) by the method of d-c bias and amplification of a-c peaks.

The oscillogram, taken during routine production, showed a welding time of about 29 cycles (60-cycle basis) in four pulses separated by pauses of $3^1/_2$ cycles. Due to the use of the positive half-cycles of voltage in the measurement of flicker and to the control of the polarities of consecutive current pulses, the voltage dips are recorded for alternate pulses only, as the positive voltage peaks coincide with the periods of zero current during every second group of pulses. Although the current waveshape is nonsinusoidal, the rms voltage drop may be calculated with sufficient accuracy on the basis of a sine waveload equal to the line frequency component of the current.[9] This approach yields for the rms voltage drop approximately 67 per cent of the difference between voltage peaks. Hence, voltage drop at the distribution panel is: 0.67 (175.2 − 171.0) = 2.7 volts; and at the service point, 0.67 (175.7 − 174.3) = 1.0 volts.

The user, recognizing that the flicker was produced by his equipment, was willing to put up with a dip of 2.7 volts but in the opinion of the observers the flicker would have been intolerable to others. On the other hand, the dip of 1.0 volt at the power company's service, while distinguishable as pulsating flicker, was judged passable.

On a sustained basis, the conditions described represent a flicker frequency of $7^1/_2$ per second, for which the charts on Figure 6 give a threshold of objection of 1.2 volts. Considering the difference in the nature of flicker, the different conditions of observation, and the tapered dip of voltage during each pulse, the good agreement between the observers' judgment and Figure 6 is interesting, but a single observation should not be used as a basis of generalization.

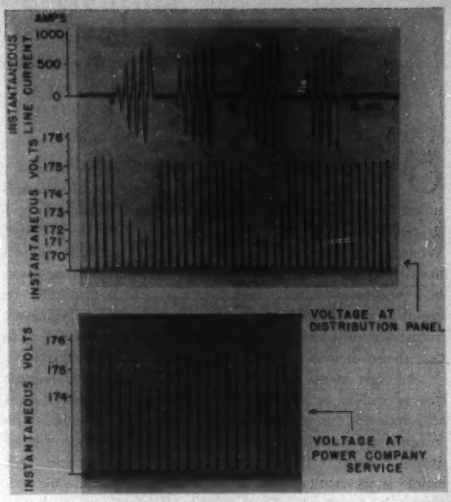

Figure 11. Voltage dips caused by frequency-changer welder

Perceptibility of cyclic flicker was discussed heretofore in terms of the frequency of pulsations. Evidence was offered herein to indicate that the duration of the voltage dip also affects flicker visibility. The new evidence does not imply fundamental changes in the presently used standards but in borderline cases it may swing the decision as to whether flicker is acceptable or not.

The additional information is not sufficient to evaluate the flicker of the frequency-changer welders because the observations were confined to sustained flicker. In view of the increasing use of the new type of welders, a systematic study of their flicker characteristic would be highly desirable.

REFERENCES

1. The Visual Perception and Tolerance of Flicker, **Electrical Testing Laboratories Report** under the direction and supervision of the Committee for Project Number 10, Utilities Co-ordinated Research, Inc., New York, N. Y., 1937.

2. Cyclic Flicker of Fluorescent Lamps, **W. R. Weise.** *Electrical World* (New York, N. Y.), volume 124, October 27, 1945, page 80.

3. Uber die Welligkeit der Lichtemission bei Wechselstrombetriebenen Leuchtstoff-Entladungsrohren, **E. G. Andresen.** *Das Licht* (Berlin, Germany), 1937, page 235; 1938, page 42.

4. The Flickering of Sources of Electric Light, **P. J. Bouma.** *Philips Technical Review* (Eindhoven, Holland), October 1941, page 295.

5. Papillotage et Phenomenes Stroboscopiques Provenant de Fluctuations de la Lumiere a la Frequence du Reseau, **Report of the Committee on Flicker.** *Bulletin*, Association Suisse Des Electriciens (Zurich, Switzerland), July 13, 1946, page 367.

6. En Sammenlikning Mellom Lysstoffrer og Glodelamper med Hensyn til Lysblunking som Framkommer ved Korte Spenningsvariasjoner, **Harald Aas.** *Electroteknisk Tidsskrift* (Oslo, Norway), 1948, number 4, page 43.

7. Three-Phase Balanced Load Resistance Welding Machines, **J. L. Solomon.** *The Welding Journal* (New York, N. Y.), May 1947, page 426.

8. Electric Arc and Resistance Welding. AIEE *Special Publication*, May 1949, pages 96–139.

9. Circuit Analysis of Frequency-Changer Welders, **W. K. Boice.** *The Welding Journal* (New York, N. Y.), October 1949, page 946.

Study of Harmonic Power Generation

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OCCASIONALLY it is desirable and even necessary to have available sources of voltage supply of harmonic frequencies. Rotating machines with the appropriate number of poles have been used for this purpose. When the power requirements are low, electronic devices may be used. This article presents results of an analysis of a nonlinear static element circuit which also may be useful as an efficient source of voltage supply of harmonic frequency of good waveform. The circuit is unique in that it uses neither rotating parts nor electronic devices.

There are many practical circuit problems which become impractical of solution by any approach other than that afforded by the availability of analogue- or digital-type computing machines. Many of these may be rather simple circuits. The problem which is discussed in this article is physically simple in that only a few circuit elements are involved. Furthermore, it is unique in that a steady-state solution is desired rather than a transient solution.

The differential analyzer approach seemed to offer the only practical and flexible approach to the solution

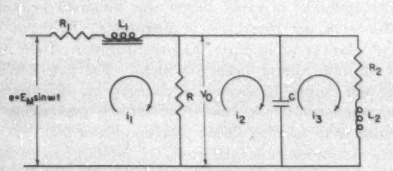

Figure 1. Schematic diagram of the circuit which was studied

of this circuit problem. The analyzer used is a completely electric high-speed device. It has characteristics which seem to render it powerful in obtaining solutions to problems of this type. While some of the special components used with the analyzer were developed in the Electrical Engineering Department of the University of Wisconsin, the standard components were built by George Philbrick Researches, Inc.

When an alternating voltage of sufficient amplitude is impressed on an iron-cored reactor, the resulting current consists not only of currents of the frequency of the impressed voltage but also those which are harmonically related to the frequency of the impressed voltage. The predominant harmonics are usually the third and fifth. If the proper linear components are inserted into the circuit, one harmonic may be amplified, the others suppressed.

One circuit capable of acting in this fashion is shown in Figure 1. In that circuit L_1 is the nonlinear inductor with inherent effective resistance indicated as R_1. L_2 and C tune the circuit to the desired odd harmonic of the impressed voltage $e=E_m \sin \omega t$. R_2 is the effective resistance in L_2. The harmonic power is assumed to be dissipated in the load resistor R. The circuit has been investigated to determine the effect on the quality and magnitude of the output voltage, V_0, of variations in the reactor characteristic, E_m, R_1, R_2, R, L_2, and C. To approach this problem with any tool short of a differential analyzer would either involve approximations which would make the results valueless or be prohibitively time-consuming, or both.

In order to make the data as general as possible, a per-unit system was adopted. As a base current for this system, the current that flows in the nonlinear inductor at the point of saturation was chosen. For base impedance, the reactance of the nonlinear inductor operating below saturation at fundamental frequency was chosen. Then the other impedances in the circuit were calculated at fundamental frequency and reduced to this base. Base volts then became equal to the product of the unsaturated reactance of the nonlinear inductor and the current in the nonlinear inductor at saturation.

In the interest of brevity, analysis of operation of the device as a third harmonic generator ($X_C/X_{L2}=9$) only is considered in this article.

A single-phase nonlinear circuit of the type studied can be used as a third (or other) harmonic power source. The output voltage is sinusoidal with a small amount of fundamental frequency and higher harmonics superimposed. By proper design of the circuit, the dominant undesired harmonic can be kept to less than 1 per cent of the output voltage. In order to keep the distortion to a minimum and yet maintain an appreciable power capacity, the following suggestions are helpful:

1. Design the nonlinear reactor so that in normal operation the impressed voltage will not be less than 1.2 nor more than 1.5.
2. Choose a core material for the nonlinear reactor so that the abruptness of saturation is a maximum compatible with waveform requirements.
3. Make C as small as waveform considerations will tolerate.
4. Critically select L_2 to give maximum third harmonic output at light loads.
5. Make R_2 as small as possible.
6. Let the value of R_1 be small, though its magnitude is not at all critical.

Digest of paper 51-172, "Differential Analyzer Study of Harmonic Power Generation with Nonlinear Impedance Element," recommended by the AIEE Committee on Computing Devices and approved by the AIEE Technical Program Committee for presentation at the AIEE Great Lakes District Meeting, Madison, Wis., May 17–19, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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Electric Home Heating

E. E. PARKS

BECAUSE OF a mild climate (3,613 degree days per year) and a very low residential power rate, electrical house heating has become so popular in the territory served by the Nashville Electric Service that at the close of 1950 over 11,000 homes were heated electrically. This represents a saturation of nearly 15 per cent. Practically all of these have been connected since 1945.

In order to insure, if possible, that each job would be satisfactory, in 1945 the company offered a new service for all prospective heating customers. At no cost to the customer, recommendations are made as to size of heaters required and an estimate of the annual heating bill is given for both old and new homes. During the past year 3,162 such recommendations were made.

Records for all electrically heated homes are maintained in a permanent file. From these records data are obtained which enable the company to improve the accuracy of their estimates on annual heating bills constantly. As an example of the type of information which is available, the averages for 526 typical homes are shown in Table I.

From such a large group of customers, it is only natural that the complaints would be numerous and varied. However, when it is considered that for the first cold month the bill for the heating customer may be double, or even triple, their usual bill for service, the surprising thing is that they are not more numerous. That electric heating has been most satisfactory is best proved by the fact that, so far as is known, not a single job once used has ever been taken out.

The problem encountered by the power company in providing service for such a large load has been great. To illustrate the effect of the heating load, in 1950 the monthly system peak demand for the Nashville Electric Service jumped from a low of 137,874 kw in July to a high of 269,000 in December. Information obtained from a study of 73 typical homes indicates that the load varies inversely as the temperature from around 12 to 76 degrees. It definitely levels off above 76 degrees to a constant, and below 12 degrees it seems to level off, although sufficient data at the low temperatures have not been available to justify any definite conclusion. This curve is shown in Figure 1.

Table I. Averages for 526 Houses

Cubic feet content	8,720
Connected kilowatts (heating only)	15.4
Annual kilowatt hours, total	19,900
Annual kilowatt hours, heating	14,100
Annual kilowatt hours, other services	5,800
Kilowatt hours per kilowatt installed	915
Watts installed per cubic foot	1.77
Kilowatt hours per cubic foot	1.62

Table II. Peak Demand for House Heating Customers

Number of Customers	Peak Demand (Per Cent)
1	70
2	64
3	58.3
4	52.6
5	46.9
6	41.2
7	36.1
8	32.4
9	30.6
10	30.1
11	30.0

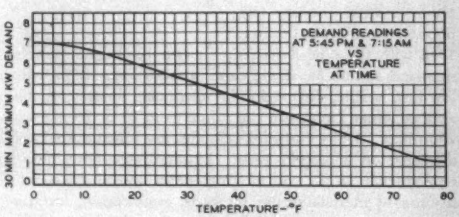

Figure 1. Kilowatt demand per customer versus temperature at the time

From all available information the Engineering Department has developed a table to be used as a guide in determining the transformer capacity required to serve a heating load. This is Table II. It is believed that maximum diversity will be reached when 11 customers are served from one transformer, and will not increase above this number per transformer.

It seems that, given a chance, people will demand electric heat even at a higher cost than for other methods of heating. In order to prove practical for all regions of the country, some method of improving the load factor must be developed. At present, the heat pump seems to offer the greatest possibility as a solution to this problem. Those now on the market, using the ground or water as a source of heat, have an efficiency of about 400 per cent. Since they are normally used as year-round air conditioning, they are an ideal load for the power distributor. Their low operating cost would insure ready sale were it not for the high cost of installation. A great deal of experimental work is being done to improve the heat pump, especially the type using the air as a heat source. The possible reward for building a practical heat pump at low cost is so great that it is undoubtedly only a question of time before it will be accomplished.

Digest of paper 51-150, "Electric Home Heating," recommended by the AIEE Committee on Domestic and Commercial Applications and approved by the AIEE Technical Program Committee for presentation at the AIEE Southern District Meeting, Miami Beach, Fla., April 11-13, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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A New Telephone Carrier System for Medium-Haul Circuits

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Low terminal costs and single cable operation make this the first economically practical carrier system for medium-haul telephone circuits. Performance is not sacrificed for economy.

THE *N1* CARRIER system is the most recent addition to the alphabetic list of Bell Telephone system carrier telephone systems which began in 1918 with the type-*A* system. It is a 12-channel double-sideband system for single cable application. It provides low-loss, stable, high-velocity telephone service for toll and exchange circuits in the range from 15 or 20 miles to 200 miles. Units and subassemblies are miniaturized and arranged on a plug-in basis. Emphasis has been placed on reduction in the cost of components and in the simplification of manufacturing methods, engineering, installation, and maintenance. Economy is achieved without important sacrifice in performance by many novel features, principal among which is a built-in low cost compandor. Other important features are self-contained dialing and supervisory signaling, individual channel regulation, and inherent equalization through the use of "frequency frogging," or interchange of high- and low-frequency groups at each repeater.

ECONOMIC CONSIDERATIONS

THE TYPE-*N1* carrier system is an important economic contribution to the needs of the operating telephone companies. It is typical of the plant of most of these companies that a large proportion of the circuits which are candidates for carrier or repeaters are relatively short. For example, in many areas, half of the toll circuits are 35 miles or less in length and only a very small proportion are over 200 miles in length. If the longer exchange trunks are included, the proportion of shorter circuits is even larger.

To obtain economies from the application of carrier to this type of plant, the carrier terminals must be relatively inexpensive; otherwise, their cost will more than offset the reduction in cost obtained by making the conductors carry a multiplicity of circuits. It is the lower cost of the type-*N1* terminals as compared to the costs of terminals for other types of cable carrier systems that permits the type-*N1* system to invade successfully the short-haul field.

The minimum length circuit that can be produced at lower costs with type *N1* than with voice-frequency loaded cable pairs and repeaters depends greatly on circumstances. For example, if type *N1* can be used to increase the capacity of an existing cable, whereas with voice-frequency methods a new cable would have to be placed, type *N1* sometimes will be economical for lengths as short as 15 or 20 miles. On the other hand, where ample cable facilities are available, type *N1* will not produce more economical circuits for distances shorter than 35 miles or so. However, the transmission advantages of carrier, as compared to voice, tend to favor *N1* in cases where the costs are a standoff.

The lower terminal costs and the fact that only a single cable is required make *N1* less expensive than any of the other cable carrier systems regardless of length, except in those cases where additions to existing installations only are required. The maximum usable length of the *N1* system is, therefore, a function of performance rather

Figure 1. Commercial installations with three 12-channel N1 terminals. Plug-in units are easily removed for inspection

Composite article based on three papers: **51-86**, "The Type N-1 Carrier Telephone System Objectives and Transmission Features," by R. S. Caruthers; **51-87**, "N1 Carrier Telephone System Apparatus and Equipment," by W. E. Kahl and L. E. Pedersen; and a conference paper "The Type N1 Carrier Telephone System—Engineering and Application," by A. B. Covey and H. R. Huntley. These papers were recommended by the AIEE Committee on Wire Communication Systems, and papers **51-86** and **51-87** were approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. None of these papers are scheduled for publication in AIEE *Transactions*.

R. S. Caruthers, W. E. Kahl, and **Ludwig Pedersen** are with the Bell Telephone Laboratories, Inc., Murray Hill, N. J. **H. R. Huntley** is with the American Telephone and Telegraph Company, New York, N. Y.

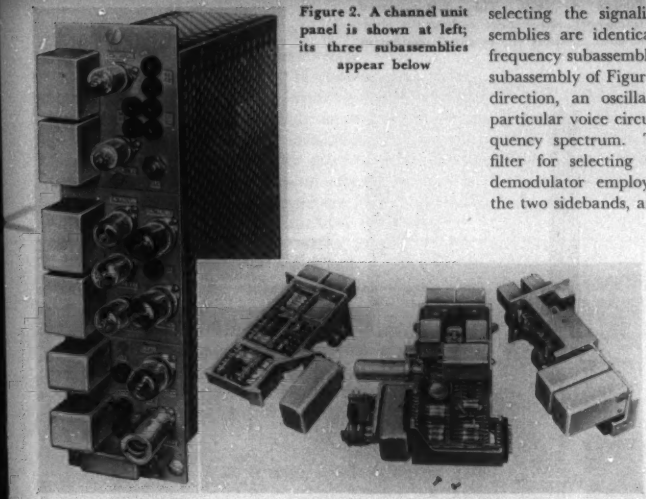


Figure 2. A channel unit panel is shown at left; its three subassemblies appear below

than of cost. To date, most systems which have been planned are under about 200 miles in length. However, it is not certain that longer systems will not have adequate performance and studies are under way pertaining to some systems as long as about 300 miles.

GENERAL DESCRIPTION

THE *N1* terminal is illustrated in Figure 1. The 12-channel terminal units and their associated common equipment occupy approximately 40 inches of space on a standard 19-inch relay rack bay. Three systems are accommodated per bay and such bays may be located back-to-back without any aisle space between rows. The plug-in channel units are removed easily for inspection as shown in Figure 1.

A close-up of a channel unit is shown in Figure 2. Its face dimensions are approximately 3 inches by 12 inches and the depth is 10 inches. In this space are the normal functions of a terminal plus an individual channel regulator, a compandor, a signaling system capable of transmitting dial pulses, and a hybrid arrangement for combining the separate transmitting and receiving paths to permit connection to a 2-wire circuit. The channel unit is made up of the three subassemblies shown in the inset of Figure 2. The top unit of the panel (left unit of the inset) is the transmitting voice subassembly. It contains the compressor part of the compandor, a low-pass filter for limiting the voice band, and a resistance hybrid with a compromise network for converting the 4-wire carrier system to 2-wire voice operation where required. The center subassembly of both views is the receiving voice subassembly. It contains the expandor part of the compandor, an "out-of-band" signal receiving circuit operating at 3,700 cycles on an on-off basis, a keyer for controlling the outgoing signaling pulses, a filter for limiting the voice band, and a filter for selecting the signaling band. These two voice subassemblies are identical for all 12 channels. The carrier frequency subassembly is the lower unit of the panel (right subassembly of Figure 2). It contains, in the transmitting direction, an oscillator and modulator for placing the particular voice circuit in its appropriate place in the frequency spectrum. The receiving side contains a band filter for selecting the particular receiving channel, a demodulator employing the carrier which accompanies the two sidebands, and an individual channel regulator of the automatic gain control type. The carrier frequency subassembly is necessarily different among the several channels with respect to the crystal in the carrier oscillator and the receiving channel band filter.

Figure 3 shows an exploded view of the receiving voice subassembly. Items of interest include the die castings used to support the components and a new method of mounting "pigtail" components. The latter makes use of plastic strips into which the leads of the elements are imbedded. This process is done in a jig and the application of heat is automatically timed. The clipped leads of the elements then form terminals for external connections, or internal strapping for which the wires are applied to the terminals by an electrically driven wrapping gun held in the operator's hand.

The framework which accommodates the channel units, their common receiving and transmitting amplifiers with associated features, alarms, and so forth, are shown in Figure 4. This framework is wired and tested in the factory. Installation consists of mounting this framework on the bay and connecting the external circuits to the terminal strip which is a part of the framework. The several channel and group units are shipped in individual

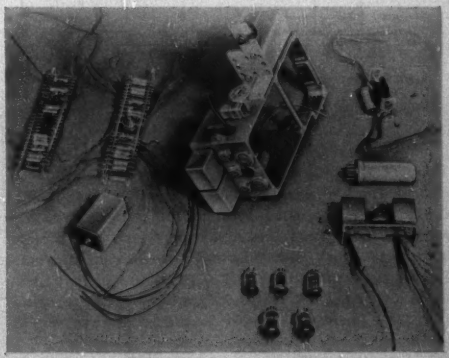


Figure 3. Components of the expander and signalling unit

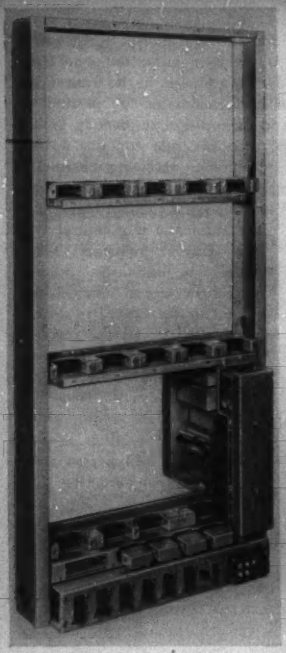


Figure 4 (left). This factory-wired framework, shown here without the plug-in units, contains the terminal equipment

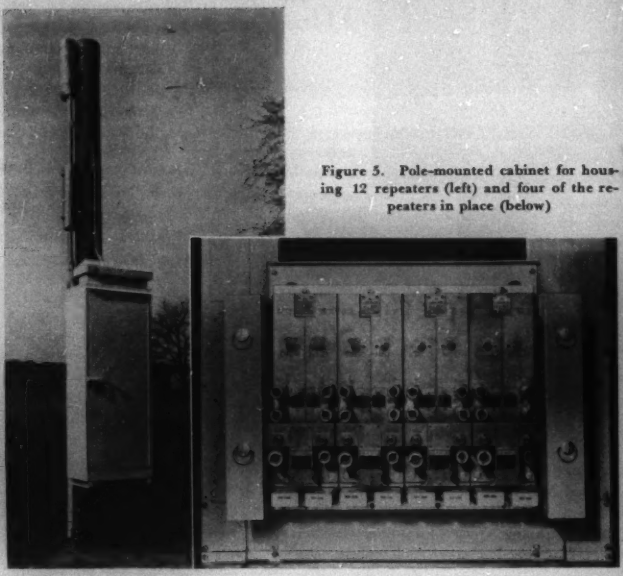


Figure 5. Pole-mounted cabinet for housing 12 repeaters (left) and four of the repeaters in place (below)

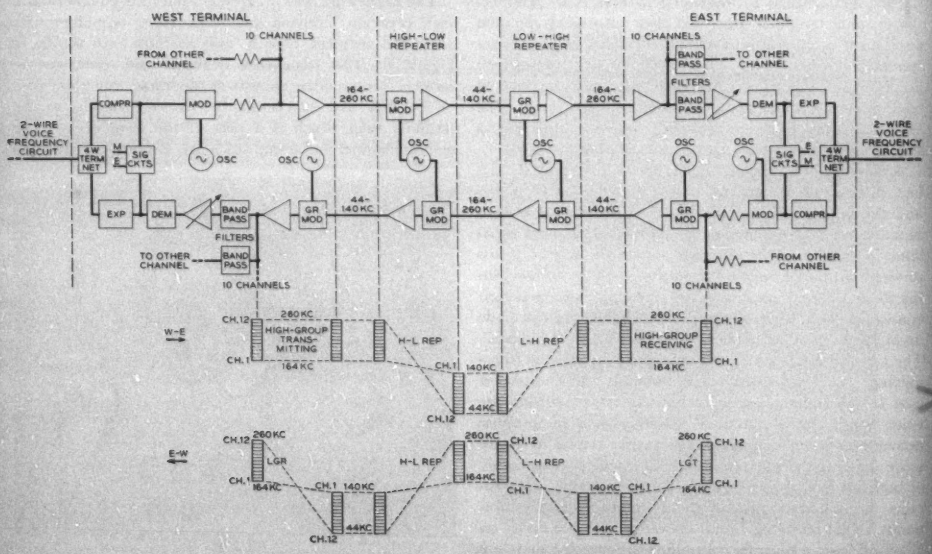


Figure 6. Basic arrangement of the terminals and repeaters, showing the frequency separation of the directions of transmission

cartons and are equipped with the same vacuum tubes that were in place during the factory tests.

The repeaters are common to 12 channels and placed at intervals of six to eight miles, depending upon the gauge of the cable conductors. As many as two out of three repeater points may employ pole-mounted repeaters. These repeaters are supplied with power over the cable conductors on a simplex basis from an adjacent terminal or powered repeater point. The latter are located in small central office buildings, either attended or unattended, and containing rectifier-battery power plants. Supply over the cable conductors is +130 and −130 volts to ground. About half the voltage is expended in the conductors and the voltage regulator at the supplied repeater. Such a pole-mounted repeater cabinet is shown in Figure 5. This cabinet can accommodate a maximum of 12 repeaters, or 144 message circuits. The repeaters are plugged into a framework much like that employed for the channel units. A group of four repeaters in place is shown in the inset of Figure 5. Extra racks are provided so that working repeaters can be switched out of service for maintenance or replacement.

TRANSMISSION FEATURES

THE GENERAL layout of the system from a transmission standpoint is shown in Figure 6. At the terminals all of the channels, transmitting and receiving, are modulated into the range from 164 kc to 260 kc. On the line in any particular repeater section, the two directions of transmission are in different frequency groups; one of these is the original group from 164 to 260 kc and the other group is from 44 to 140 kc. These groups accommodate the two 4-kc sidebands and transmitted carrier for the 12 channels. The frequency groups are "frogged," or interchanged, and inverted in each repeater by a built-in modulator. The translation from the high group to the low group at the terminals is accomplished where required by modulators in the group amplifiers. To accommodate all the combinations which may occur, it is necessary to provide repeaters which convert high group to low group in both directions and low group to high group in both directions. Transmitting and receiving group units are furnished to transmit or receive either high or low groups at the terminals.

The employment of the high-frequency band in the channel units simplifies the design by eliminating the need for transmitting band filters, since no important modulation product of any channel falls within the band of any other channel, and because for this frequency range the elements of the receiving band filters can be made small and inexpensive. The use of two frequency groups for the two directions and the frogging of these groups have two important effects. The first effect is concerned with possible spurious transmission paths which would be undesirable from the standpoints of crosstalk and singing. The other effect affords inherent equalization of systems.

The importance of this inherent self-equalization is illustrated by Figure 7. The solid curves are the plot of loss in decibels for 10 repeaters (11 cable sections) against frequency. The dashed line associated with the solid line indicates that for the ranges chosen for the high and low groups the frequency characteristics are nearly linear. If the high and low groups were not interchanged, the average losses in the two directions would differ by approximately 200 decibels, and the accumulated slopes in the two directions would be of the order of 200 decibels. When the two groups are interchanged and inverted, as indicated by the arrows in the figure, the average loss for the two directions is made approximately the same, and the slopes tend to cancel, so that, for the example chosen, the residual differences between the actual values and the linear example are only a few decibels. Equalizers are provided for the longer circuits to minimize this residual,

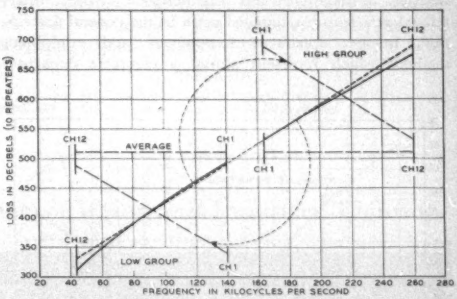


Figure 7. Equalization by frequency frogging and inversion

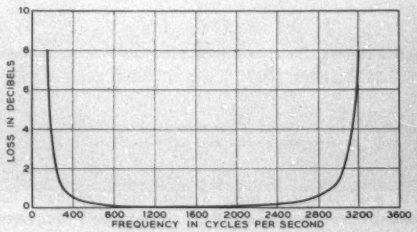


Figure 8. Typical channel low-frequency characteristic

which is reduced still further by the action of the individual channel regulators, within their operating ranges.

A typical frequency characteristic is shown in Figure 8. The 3-decibel points are at frequencies of approximately 200 cycles and 3,100 cycles. Comparison of a multilink condition of type-*N* systems having the typical frequency characteristic shown, as contrasted with somewhat wider bands with sharper cutoffs, indicates that from a transient standpoint there is much to be said in favor of the frequency characteristic of the type-*N* system.

The principal factor in determining the shape of the upper frequency cutoff is the low-pass filter in the receiving voice subassembly. This characteristic is plotted in Figure 9 together with a band-pass characteristic of the

signaling system. A dual problem exists, in that interference cannot be tolerated either from voice to signaling or from signaling to voice. This interference is minimized by removal of the signaling frequencies during conversation, by the use of limiting in transmitting voice subassembly, and by compandor action. The general effect of the compandor is an improvement of 20 decibels or more in noise and crosstalk effects, which can be translated directly into easing of filter requirements, raising of transmission levels, and so forth.

APPARATUS AND EQUIPMENT PHILOSOPHY

IMPORTANT as new circuit techniques are, they alone cannot insure minimum cost of manufacturing, engineering, installation, and maintenance. Many interrelated new features, touched upon in the general description, involve apparatus components and equipment methods which represent almost a complete departure

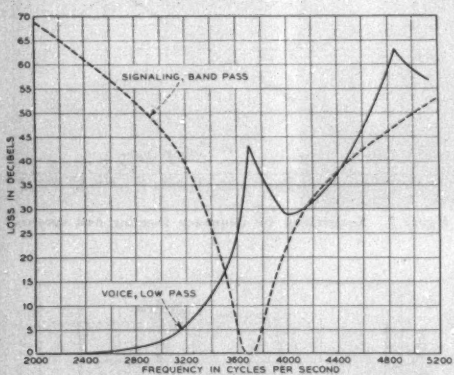


Figure 9. Receiving filter loss-frequency characteristics for separating voice and signaling circuits

from past practice. Size, weight, and cost have been markedly reduced by arranging miniaturized components compactly in die-cast aluminum frameworks of such size and shape as to utilize rack space efficiently in depth as well as in breadth and height. This approach has been termed "cubic" construction, as contrasted with the "planar" arrangements of conventional panels.

Considerable planning has entered into the division of units into subassemblies from the standpoints of easing the problems of the circuit designer, the manufacturing engineer, the merchandising engineer, the fundamental planning engineer, the installer, and the maintenance man. Parts must be readily accessible, critical lead lengths must be no longer than necessary, temperature rise of particular items must be within limits, and so forth. Controls for adjustment of the system are divided between those which must be located on the front panel for ready access, and those which can be placed inside the unit and reached only by removing the unit from its mounting.

The plug-in method of mounting permits testing without the necessity for expensive jack fields. A unit or subassembly in trouble can be replaced rapidly. It can be tested at a convenient time in a convenient place. In certain types of testing the unit can be removed from its mounting, and the circuit restored by patch cords through the original unit in an accessible position in a bench mounting for test and adjustment. Testing equipment ranges from very simple test sets for use by linemen, through more complex devices for central office use, up to a complete arrangement for use at maintenance centers which can perform most of the tests required in manufacture.

When it was noted that methods of mounting and wiring radio type components easily might cost double the price of the component, new methods were devised for imbedding the pigtail components in plastic strips by automatic methods. A pistol-type wrapping gun speeded up the operation of wiring to these components and improved the wrap as compared with hand operation using pliers.

Die-cast chassis frameworks initially involve expensive dies, but are economical for such a system as type *N* for about 100 systems, or a fraction of a year's output. The castings are uniform in dimensions, facilitating assembly and interchangeability of parts. The surfaces as originally cast require no finishing operation. Designations for tubes and similar components are incorporated as raised characters in a recessed area. In spite of the complexity of the casting, as illustrated by Figures 2 and 3, the average cost of die castings in the *N* system is of the order of one dollar, which is a fraction of the cost of similar fabricated frameworks. Many new components are used extensively in the *N* system. It is characteristic of these components that in many instances the small size leads to improved performance. Distributed parasitic capacitances, for example, are greatly reduced. In other instances new techniques are involved.

In the channel band filters standard radio-type parts are used. The coils for all frequencies are alike. The different frequencies are accommodated by varying the spacing of coupled coils, and by different sizes of tuning capacitors. The coils and capacitors meet only normal commercial limits, and the final close adjustment of the filter is made by screwdriver operation of slug-type tuning elements.

The transformer designs feature the use of very fine wire and multiple, or "stick," winding. When possible, cores are split and cemented after assembly with the winding. One of the signaling transformers is adapted from a hearing aid design.

Nearly 800 germanium varistors are used in a typical *N* system. These perform a variety of functions as modulators, demodulators, vario-lossers, rectifiers, signaling keyers, voltage doublers, current dividers, and so forth. These must meet varying degrees of precision over a wide range. Economy is achieved by a factory selection process in which the universe of the product is progressively allocated to the various uses in order of precision.

Compression of several microfarads of capacitance into a small space is one of the imperative needs of miniaturiza-

tion. In the type *N* system long-life, relatively close-limit tantalum capacitors are employed. Two types, sintered and foil, are available in various combinations in polar and nonpolar form, for 60 and 150 volts. About 200 such capacitors are used per system. It is interesting to note that the 4-microfarad 60-volt polar capacitor is approximately 1/4 inch in diameter by 1/2 inch in length, exclusive of leads.

Certain problems have been met in the electrical and mechanical design of the type-*N* system which are fundamental. Some of these will require time for complete resolution:

1. The design must be worked over through several models to insure stability in manufacture. Consequently the cost of development may appear proportionally high as compared with previous developments, but the saving also is proportionally high.

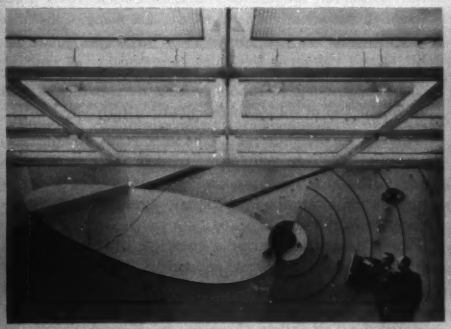
2. The concentration of tubes and other power consuming components at the terminals creates a problem of heat dissipation when the room ambient temperature is high. This has been solved by the use of a blower which is controlled by a thermostat mounted on the bay. As the percentage of miniaturized equipment increases more basic methods, such as air conditioning, may be required to maintain a suitable operating temperature.

3. The optimum degree of miniaturization from the several standpoints has not been determined. There is undoubtedly a point of diminishing return beyond which it is unproductive to go. To the point represented by the *N* system, negative factors such as difficulty in manufacture have not been serious. This statement excepts the heat dissipation problem noted in 2.

REFERENCE

1. Application of Compandors to Telephone Circuits, **C. W. Carter, A. C. Dickieson, D. Mitchell.** AIEE *Transactions*, volume 65, 1946, pages 1079–85.

Lighting Center Illustrates Essential Facts of Vision and Industrial Lighting



A multipurpose Lighting Mobilization Center, designed to demonstrate how lighting affects seeing, how it improves visibility of the seeing task, and how it creates a pleasant environment for workers, has been opened at Nela Park, headquarters of the General Electric Company's Lamp Department, Cleveland, Ohio.

The heart of the center is a compact room with a seating capacity of 90 persons. The 12-foot high ceiling (photograph at left) features "100 lighting systems in one," and makes possible the demonstration of numerous lighting systems obtainable today.

A huge mural on one of the side walls of the room (above, left) is devoted to the three factors essential to seeing, namely, the eye, the task to be performed, and the light source. Expanding rings of a giant bull's-eye pattern suggest the manner in which light emanates from an incandescent or mercury lamp. A large prism, containing a special chemical solution, breaks up light from a light source into its various colors, fanning them out to form a greatly enlarged lamp spectrum. This is shown in the photograph at the right. Characteristics of the sun's radiations, their quantity and quality, and the sensitivity of the human eye to various wave lengths are indicated also on this mural.

The center's other side wall area is devoted to demonstrating how colored lighting may be used to make seeing easier in various industrial production processes.

Audience participation is provided in connection with the use of the center's ceiling and the mural setup. This is done by providing each person in the audience with assortments of typical industrial seeing tasks to be performed by the individual himself. These tasks are designed to drive home the facts about the amount of light required for top production in industry, as well as the facts regarding reflection, glare, color shadows, speed, and accuracy of vision.

A High-Current Thyratron

A. W. COOLIDGE, JR.
ASSOCIATE AIEE

The GL-5855, a new inert-gas-filled thyratron, has massive anode and grid elements sealed directly to a heavy-walled glass envelope. These elements, therefore, are cooled by convection as well as by radiation, permitting full-load operation with low grid current.

INERT - GAS - FILLED thyratrons are being widely used in industrial control applications because of their short warm-up time, ability to operate over a wide ambient temperature range, and freedom from mounting restrictions. A line of gas-filled thyratrons has been described in which some of the restrictions of earlier tubes have been eliminated.[1] The tube to be described here is the *GL-5855* which is an addition, with higher current ratings, to this line, but its structure is quite different from that of its predecessors. It has peak and average current ratings of 150 and 12.5 amperes respectively, a peak forward and inverse anode voltage rating of 1,500 volts, and a 2.5-volt filamentary-type cathode with a 1-minute heating time.

DESIGN

THE *GL-5855* represents a novel approach in the construction of thyratrons; however, the design utilizes certain principles that have been time-tested in transmitting and ignitron tubes.

For many years high-powered transmitting tubes have had one or more of the elements external and integral with the tube envelope. In the case of tubes for extremely high frequency, the design often is dictated by the requirements of minimum lead length and minimum inductance between the tube elements and their respective circuit. In the field of low-frequency tubes, the only reason for external elements is to provide more effective cooling of the elements through convection.

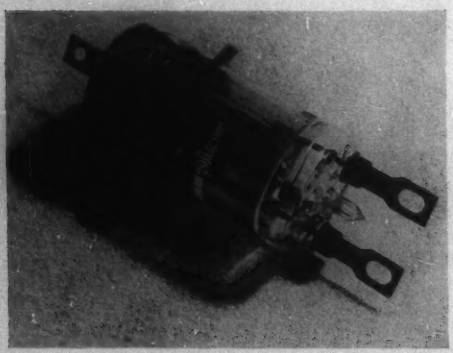


Figure 1. The GL-5855 thyratron is approximately 11 1/16 inches high and has a diameter of 3 3/8 inches

As considerable dissipation takes place at the anode and grid of a thyratron conducting 12.5 amperes average, it was felt that grid emission could be eliminated by designing both the grid and anode as external elements, thereby assuring a minimum operating temperature of the grid.

Ignitron tubes having high current ratings have been designed without bases universally. These tubes are mounted by heavy steel terminals which can be bolted securely to the panel in which they are used.

This type of mounting has proved to be very satisfactory, and the same principle has been carried over to the *GL-5855*. However, the use of a base and socket on a high-current thyratron might lead to the following difficulties in application:

1. Dried-out basing cement causing a loose base.
2. Poor contact in socket causing overheating of and consequent loss of solder in the filament pins.

These types of failure could be very costly to the user, especially if the tube were being used in conjunction with a critical continuous process. By using heavy strap terminals for mounting and electric connection the difficulties are eliminated.

Figures 1 and 2 illustrate a complete tube and a cross section of the *GL-5855*. As is evident, the edges of the anode and grid elements are sealed directly to the glass envelope. Anode and grid seals are fabricated from an iron-nickel-cobalt alloy (Fernico or Kovar) calculated to have a coefficient of expansion sufficiently close to that of the associated glass to allow the seals to be made, annealed, and caused to undergo subsequent temperature cycles during operation without fracture.

The grid consists of two Fernico cups, slotted at the center. These are welded and copper-brazed together back-to-back in such a way that the slots are aligned. A short bracket attached to the outer rim of the cups serves as the grid terminal.

The re-entrant anode is a 3-piece assembly made from a Fernico flange, deep-drawn iron cup, and thick iron disk. The cup is drawn the full height of the anode with flange, at the top, and disk, at the bottom, welded and copper-brazed to the cup. The disk has a twofold purpose. First, it provides good thermal conductivity, thus preventing

Essential text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 22-26, 1951. Recommended by the Committee on Electronics.

A. W. Coolidge, Jr. is with the General Electric Company, Schenectady, N. Y.

overheating of the center of the anode during operation. Second, the mechanical strength provided by the disk is necessary to prevent the bottom surface from buckling under the atmospheric pressure and thereby contacting the grid surface. An incidental characteristic provided by the thick disk is large thermal capacity.

The anode and cathode terminal straps are welded and copper-brazed to their respective seal assemblies. A hole in the anode terminal permits mounting on a bolt as large as one with a 3/8-inch diameter. The openings in the cathode terminals are elongated and wide enough to allow for variations in the over-all length of the tube and for variations in the positioning of the mounting bolts.

COMMUTATION FACTOR

In addition to those previously discussed, an important rating for an inert-gas-filled thyratron is the commutation factor rating, which is 200 for the *GL-5855*. Commutation factor is defined as the product of the rate of current decay in amperes per microsecond just prior to commutation and the rate of inverse voltage rise in volts per microsecond just after commutation. High commutation factor operation is to be found most widely in multiphase circuits, employing an inductive load where the load current is continuous.

If a tube is operated in excess of its commutation factor rating it is subject to rapid clean up of the gas as a result of excessive ion bombardment of the anode. To prevent clean up of gas in tubes having low commutation factor ratings, it is sometimes necessary to modify the circuit to reduce either the rate of decay of current or the rate of rise of inverse voltage, and consequently the commutation factor, to within the rated value. The rate of decay of current may be reduced by adding reactance in series with the transformer windings, while the rate of rise of inverse voltage may be reduced by adding a series resistor and capacitor connected between the anode and cathode of each thyratron. Additional expense and maintenance are involved in circuits requiring these modifications. In the line of tubes described in the literature, the high commutation factor rating was attained by using a design in which positive ion bombardment of the anode is held to a minimum by:[1]

1. Close spacing between anode and grid resulting in a minimum number of ions being affected by the anode field at the end of conduction.

2. Thorough shielding of the anode leaving only a small portion of its area available for ion bombardment.

From the cross section, Figure 2, it is apparent that these conditions also are fulfilled in the design of the *GL-5855*. Although the anode actually has no shield surrounding it, the effective shielding is complete inasmuch as the top surface of the anode is external to the tube and hence cannot possibly be influenced by mobile ions inside of the tube. As in the previously described line of tubes, the close anode-to-grid spacing also permits loading the tube to the highest possible gas pressure.

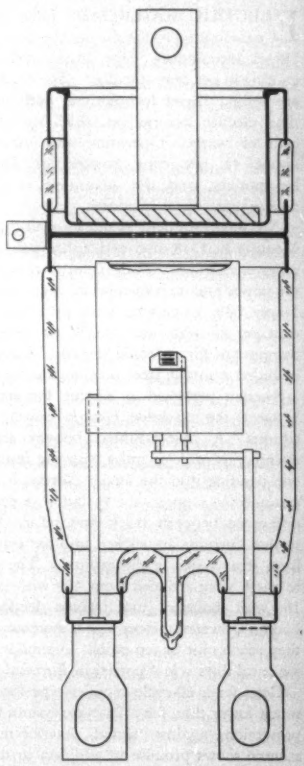


Figure 2. Cross section of the GL-5855

Table I. Test Conditions

	Per Tube Values
1. Average current, amperes	12
2. Peak current, amperes	30
3. Peak inverse voltage, volts	1,175
4. Rate of rise of inverse voltage in volts per microsecond	120
5. Rate of current decay in amperes per microsecond	1.5
6. Commutation factor (product of items 4 and 5)	180

Tubes are being tested under conditions shown in Table I, in a circuit having an inductive load and in which the load current is continuous. In this test the tubes are being commutated under the worst conditions, at the instant when the transformer voltage is maximum.

As is the case with the other tubes in the line, the commutation factor rating for the *GL-5855* is high enough to obviate the need of circuit modifications in most industrial control applications.

REFERENCE

1. A New Line of Thyratrons, **A. W. Coolidge, Jr.** AIEE *Transactions*, volume 67, part II, 1948, pages 723–7.

Electric Railways on Central Station Power

LLEWELLYN EVANS
FELLOW AIEE

ELECTRIC RAILROADS have made no per cent gain in total traffic during the past ten years. Trucks, Diesel locomotives, pipe lines, and canal systems are gaining in per cent of traffic. The electrical manufacturers are selling Diesel locomotives, and indirectly oil, rather than electric locomotives which use power generated by coal or water. Operating and maintenance costs are about 44 per cent greater for Diesel than electric locomotives, and the advantage of electricity increases as the price of oil increases.

A symposium held at the Pittsburgh, Pa., AIEE Winter Meeting in 1948 analyzed a medium traffic section of 330 miles of railroad. Three central station networks supplied the power and no transmission was required by the railroad. Power bills, calculated from published rates, were 0.686 cent per kilowatt-hour at 157 per cent of normal traffic. Suggestions for reducing the cost of trackside construction included a simple steel pole arrangement.

Sweden perfected a scheme for reducing interference between the trackside electric power system and signal circuits. A pole-mounted booster transformer is used at intervals of three miles with the return track current in one winding and the feeder current in the other winding arranged to suppress the variation in each. The potential difference between track and return feeder is increased so that currents are sucked into the return wire and away from stray paths in the ground. The disturbing voltages to earth were reduced from 400 with no booster to under 15 with boosters and return feeders. Regardless of boosters, Sweden places signal systems underground when they reach nine or ten pairs. A similar sucker transformer for rural lines was reported in *Electrical World*.[1]

Costs for a 60-cycle rectifier-type locomotive system are much lower than for a 25-cycle system for all items except protection against signal interference. The Swedish scheme shows promise in addition to the schemes already proposed for the rectifier locomotive. A rectifier locomotive is expected to cost 80 per cent of the equivalent a-c series motor locomotive, and 60-cycle transformers cost 67 per cent of 25-cycle units. An investigation of 2,318 route miles through a representative power network indicates that the 60-cycle system, including trackside construction, would cost 64 per cent of 25-cycle supply. Single-phase lines were used from primary substations to trackside metering points and phase-balancer sets were added where needed.

The general scheme would equip a rectifier-type locomotive with 1-hour battery capacity to last between supply points, and electrify the track with 13.2-kv trolley at stations, at certain side tracks, and on heavy grades. The amount of trolley required amounts to less than one-third of full electrification and can be made simply.

A railroad would put trolley over a limited stretch of its tracks, buy central station power at standard frequency and voltage, and finance the locomotive much the same as now. This combination reduces the railroad investment for fixed structures to under $10,000 a mile of route electrified. The central station runs service wires and sets meters at feed points. Short peaks at many substations could be carried in the overload capacity of the present transformers and regulators. Rates already established would automatically provide revenue to pay for capacity.

An extensive investigation was made of four different types of storage batteries for use instead of the gas turbine, and so forth, of the 4,500-horsepower Alco General Electric locomotive. The lead battery is too heavy and would require a tender. The Edison battery and the nickel-cadmium battery have rather large total weight and volume when groups of low-capacity cells are connected in parallel, but the use of a smaller number of larger ampere-hour capacity cells may have possibilities for use.

The Silvercel battery manufacturer (Yardney Electric Corporation, New York, N. Y.) has published data on cells up to 60 ampere-hours and larger cells have been built. By extending data available, the weight of a 600-ampere-hour cell is 0.5 ounce per ampere-hour stored—equal to 35 pounds per kilowatt-hour at 1-hour discharge rate. In an experiment, the one ampere-hour cell was charged and discharged at five amperes and also discharged at ten amperes for three minutes with no signs of injury. A cell half the size of a brick delivered 400 amperes for several minutes at a temperature that would not burn your fingers pressed tight on the case. The life of the Silvercel has been found to be better than a lead battery but not as good as a nickel iron (Edison) battery.

The estimated cost of a Silvercel battery is $379,000 per 4,500-horsepower locomotive, of which $346,000 is the value of silver which does not waste away but remains at full value. A lead battery with equal power for one hour now costs $292,000. Many alternate combinations of discharge rates can be made to fit different profiles, loads, and time schedules.

The railroader's preferences for a locomotive having power aboard, small investment for fixed plant by the railroad, and an improvement that can be made a little at a time are satisfied by a battery locomotive. A rectifier charger makes both 25- and 60-cycle power equally usable and adds flexibility. The rectifier-battery locomotive possibilities appear to be very tempting for exploitation.

Digest of paper 51-222, "Railway Electrification—A Prospective Consumer of Central Station Power," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25-29, 1951. Not scheduled for publication in AIEE *Transactions*.

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REFERENCE

1. Sucker Transformer Reduces Induction, **T. H. Sealy.** *Electrical World* (New York, N. Y.), volume 120, October 30, 1943, page 80.

Carrier-Frequency Noise on Power Lines

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ONE OF THE basic criteria of the performance of any communication or signalling circuit is its signal-to-noise ratio. It is possible to estimate the signal that will be delivered to a receiving point by a power-line carrier transmitter, but the noise level also must be known for the signal-to-noise ratio to be predicted.

To establish bench marks for estimating carrier-frequency conducted noise on power lines, the authors have undertaken a program of noise measurement on representative lines of various voltage classes and types of construction. A necessary preliminary step in this program was a study of some of the theoretical aspects of noise, in order to establish the properties of noise most likely to affect carrier channel performance and the necessary techniques for measuring them.

Noise is classified broadly into two general types—random noise and impulse noise. Random noise has a continuous frequency spectrum, resulting from the random occurrence of an infinite number of elementary discharges or fluctuations that are not in themselves separately distinguishable. The output of a communications receiver to which this type of noise is applied is a soft hissing or rushing sound. The peak, rms, and average values of the response of a receiver to random noise are proportional to the square root of the receiver bandwidth.

Impulse noise arises from discrete, sharp electric discharges. Although both random and impulse noise are present on power lines, the tests reported in the companion paper[1] indicate that impulse noise is predominant. This type of noise gives rise to the harsh, raspy buzz, along with random clicks or pops, that are characteristic of a power-line carrier communications channel with poor signal-to-noise ratio.

If an impulse is of such short duration that the system to which it is applied does not respond appreciably before the impulse is completed, its operational form is simply Ap, where A is the force-time area of the impulse. This indicates that the response of a receiver to a sharp impulse is independent of the actual amplitude or shape of the impulse, provided saturation or limiting does not occur. The ultimate harmful effects of noise occur in the end device connected to the receiver. In specifying the parameters of impulse noise, therefore, it does not appear necessary to know in detail the characteristics of the pulses as they appear at the input terminals of a receiver, because the pulses are modified radically in passing through the receiver. Rather, what is required is a knowledge of the characteristics of the noise after passage through a calibrated receiver (that is, a noise meter) of known bandwidth and of suitable detector characteristics. The response of the noise meter then can be translated to a bandwidth corresponding to that of the actual carrier receiver to be used in the communication system.

Knowledge of three different values of response, namely the peak, quasi-peak, and average values, appears necessary to evaluate the effects of a given impulse noise on the operation of the usual types of carrier channels. The peak value of the response is important in automatic-simplex communication channels, because the automatic switching units respond to noise peaks when they exceed a certain preset level. In other types of communication channels, impulse noise produces a masking or annoyance effect which is roughly a function of the peak value of the response and the repetition rate of the impulses. The American Standards Association has standardized the charge and discharge time of the detector circuits used in radio noise meters so as to give a "quasi-peak" value of noise response proportional to this effect. The quasi-peak value is near the peak value of the response for pulse repetition rates in excess of about 15 pulses per second. In telegraphic types of carrier channels, the average value of the noise response is important, because the polarized d-c relays usually used in the detector circuits respond to the average detector output current.

The peak response of a receiver to impulse noise is directly proportional to the bandwidth of the receiver, its mid-frequency gain, and the volt-time area of the original impulses. The average response, however, is independent of the bandwidth for the pulse repetition rates and the bandwidths normally encountered in power-line carrier applications, but it is proportional to the other two factors and the pulse repetition rate.

Complete determination of the noise level at a given point on a power system should include measurement of peak, quasi-peak, and average noise over the carrier spectrum with a noise meter of known bandwidth, a record of the approximate pulse repetition rate as determined by oscilloscope observation of the noise meter output, and a continuous record of a representative noise response over a variety of weather and switching conditions. Ordinary carrier receivers calibrated on continuous-wave signals, or other instruments not provided with quasi-peak weighting circuits, in general provide information only on the average value of noise response, which is not indicative of the actual masking or annoyance effect of impulse noise in voice communication circuits.

Digest of paper 51-187, "A Study of Carrier-Frequency Noise on Power Lines—Theoretical Considerations and Measuring Techniques," recommended by the AIEE Committee on Carrier Current and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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REFERENCE

1. A Study of Carrier-Frequency Noise on Power Lines—Part II. Results of Field Measurements, R. C. Cheek, J. D. Moynihan. AIEE *Transactions*, volume 70, part II, 1951 (*Proceedings TT-245*).

Effects of Series Capacitors in Transmission Lines

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THE LOAD capability and performance of high-voltage transmission lines can be improved by the installation of series capacitors. Some reasons for the application of series capacitors to transmission circuits are:

1. To effect the desired load division between parallel circuits.
2. To increase the load capacity of a transmission line by a nominal amount (0 to 50 per cent).
3. To provide increased line capacity so that the system can handle short-time emergency loads.
4. To increase the transient stability limits of a system.
5. To improve voltage regulation and power factor for a given load condition by reducing the operating angle of the line.

There are several ways to analyze the effects of series capacitors on power transfer ability. One method is to assume typical values for terminal impedances in order to calculate the stability limit for various line lengths and percentage series compensations. When this method is used, the terminal impedances are decreased as the transmitted power is increased to simulate an increase in generator and transformer capacity. Such an approach yields complete information about the assumed system, but there are certain cases where data obtained by this means are not applicable.

In order to analyze such cases, a second approach to the problem must be taken. The assumption is made that most long lines are operated with fixed or predetermined high-side voltages at the sending and receiving ends. Therefore, the performance of the line and the series capacitor can be considered separately from the terminal equipment and can be analyzed with respect to line voltage, voltage gradient, operating angle, and ratio of resistance to reactance (r/x).

The transmission lines on either side of the series capacitor are represented by *ABCD* constants as defined

$$E_s = AE_r + BI_r \tag{1}$$

$$I_s = CE_r + DI_r \tag{2}$$

The *ABCD* constants are used because it is desired to show the effects of line resistance and line shunt capacitance, and this method offers the easiest analytical approach. Terminal impedances are not included because it is desired to illustrate the effects of series capacitors on the performance of transmission lines without the masking effects resulting from consideration of various terminal impedances. Series capacitors had the following effects:

1. The power transfer ability of a line with 50-per cent compensation is approximately equal to that of two parallel lines of the same length and voltage.
2. The power transfer ability of a 138-kv line with 75-per cent compensation is approximately equal to that of a 220-kv line without compensation.
3. The power transfer ability of a 220-kv line with 75-per cent compensation is approximately equal to that of a 345-kv line without compensation.

A general explanation of the effect of series capacitors on power factor is somewhat involved because the effect is the cumulative result of two factors: the effect of increased resistance-to-reactance ratio (r/x) caused by series compensation, and the effect of line shunt capacitance as series compensation is increased. The reactive power flow is affected by varying amounts of series compensation.

A common fallacy in the application of capacitors is that a given amount of capacitive volt-amperes will cause the same power-factor correction whether the capacitance is placed in series or shunt. The primary reason for the disparity in the amount of capacitive volt-amperes required for each case is the increase in the total r/x ratio of a transmission line when series capacitors are used. This forces the sending-end machines to put more negative reactive power into the line than is required when the same power is transmitted over the same line without series capacitors. Therefore, to maintain the same receiving-end power factor with and without series compensation a greater amount of capacitive volt-amperes are required with compensation to absorb the increased negative reactive power input at the sending end.

Line resistance is an extremely important consideration in the application of series capacitors to transmission circuits. It is one of the principal factors that determines the maximum practical per cent compensation in a given transmission circuit. The power-transfer ability of a line decreases very rapidly with high values of compensation and with increasing values of r/x, because the power transfer becomes more a function of voltage difference between the ends of the line than angular difference.

The r/x ratio directly determines the line efficiency. The line efficiency is relatively independent of line length and voltage gradient for a fixed line operating angle.

The position of the series capacitor is an important consideration in the case of long transmission lines where shunt capacitance cannot be neglected. The studies show that the series capacitor should not be placed at the sending end of the line and that more compensation per ohm of capacitance is obtained when the capacitor is at the center of the line. Where power is transferred in one direction only, satisfactory operation can be obtained with the capacitor at the receiving end.

Digest of paper 51-89, "Fundamental Effects of Series Capacitors in High-Voltage Transmission Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22-26, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

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A Teleprinter Signal Bias Meter

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IN TIME-division telegraphy intelligence is transmitted from one station to another by a prearranged code relating the symbol to be transmitted to a combination of unit time intervals. At the station of origin these combinations are set up by the contacts of the operator's keyboard, and upon reception at the distant terminal they reappear in the magnet of the receiving teleprinter. However, in a complex modern telegraph system, these simple states exist only at the sending and receiving points, and in transmission over the various media now available the fundamental form of the signal impulse very likely will be translated into one or more other forms of electric energy as the useful frequency spectrum of the interconnecting facility is subdivided to obtain the maximum number of individual channels of communication. This maximum usefulness can be achieved by frequency subdivision where the original signal disappears in the modulation of a carrier frequency that, in turn, is channelized by frequency selective networks, or the facility may be subdivided on a time division, a multiplex basis, or a combination of both processes. On the other hand, the frequency spectrum of the line between the stations may be so narrow that only a single teleprinter channel can be accommodated, and if this line is long electrically, the make-break signals will be converted to the 2-current or polar form at the relaying stations for best operation.

If the response of the device relaying the demodulated signal to a teleprinter line is not symmetrical, the signal unit intervals of one sense will be shortened or lengthened at the expense of those of the opposite polarity. This form of signal distortion can be measured and corrected during the normal flow of traffic without special test signals with the aid of the teleprinter signal bias meter.

Regardless of the manner of transmission, the unit time intervals, after frequency selection and demodulation or time selection, will be distributed to the receiving teleprinter in the form of single-current or make-break impulses. These unit intervals have two dimensions, the magnitude of the operating current and its time of duration; and while the teleprinter exhibits considerable tolerance to variations in these dimensions either the wide-band telegraph system or the relatively simple d-c telegraph line presents opportunities for changes to occur either in the modulation and demodulation processes in the more complex systems or simply because of lack of symmetry of response of relaying devices in the case of the narrow-band line.

Since all receivers have the same impedance, the magnitude of the operating force can be regulated fairly well by adjusting the current in the teleprinter lines to a uniform level; current regulation is effected readily with the line milliammeter and rheostat. This article describes a somewhat more elaborate meter by means of which the second dimension of the signal unit interval, its time of duration, can be measured as simply and easily as the first, without the necessity of special test signals or the interruption of the normal flow of traffic. With the aid of this meter, the operating technician also can reduce any consistent distortion in time of the unit intervals, familiarly known as signal bias, to zero or tolerable limits.

The greatest number of the basic or unit signalling channels in use at the present time are designed to have a passband sufficiently wide to permit operation of a single teleprinter circuit. In teleprinter or semisynchronous signalling, the intelligence of a single character is contained within the various combinations of the 5-unit Baudot code with each group preceded by a start impulse or open-line interval to initiate operation of the receiving device and followed by a closed-line interval to bring all apparatus to a stop in anticipation of the next character. Any character, therefore, consists of a total of seven unit intervals, and there are two variations of this code of sufficient importance to be met by the teleprinter signal bias meter.

In the uniform 7-unit code all unit intervals are of the same time duration when transmission is continuous at a maximum rate of 396 characters per minute; for the nonuniform 7.42-unit code the stop interval is made 42 per cent longer than the preceding six impulses, and the maximum rate of transmission is reduced accordingly to 368 characters per minute. A little calculation will show that irrespective of the code of the signals, a single spacing or open-line unit interval will have a normal time of duration of 22 milliseconds, and so to have general use the bias meter has been designed to measure the time length of spacing impulses alone. Any departure from the norm is indicated as marking or spacing bias depending on whether the unit spacing intervals are consistently shorter or longer, respectively, than 22 milliseconds.

A circuit frequently employed for the measurement of time intervals is a series combination of a resistor and a capacitor where elapsed time after the application of a battery can be determined by a measurement of the potential developed across the capacitor. This device

Full text of paper 51-5, "A Teleprinter Signal Bias Meter," recommended by the AIEE Committee on Telegraph Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 22–26, 1951. Not scheduled for publication in AIEE *Transactions*.

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is used in the teleprinter signal bias meter with an added refinement to increase the precision of measurement. Being practical about the magnitude of the signal biases to be encountered and reduced, the range of the bias meter may be limited to the measurement of signal bias not in excess of 25-per cent spacing or marking, and the charging of the timing capacitor need not begin until the signal unit interval has persisted for three-fourths (16.5 milliseconds) of its normal time of duration. If this restriction is accepted, and it is an eminently practical one, the rate of build-up of voltage across the capacitor at the end of a normal-length spacing impulse is nearly three times more rapid than if charging had been initiated at the beginning of the signal impulse. The resulting 2-per cent accuracy of observation is sufficient for proper circuit maintenance.

In order that the response of the bias meter shall be unaffected by the waveform or magnitude of the teleprinter line current and, therefore, independent of the amount of cable or the number of teleprinters in the line, the actual time-measuring circuit components are operated by an electronic relay. The latter is a trigger or balanced flip-flop vacuum-tube circuit characterized by possession of only two stable states; one tube or the other alone can be conductive. This electronic relay is coupled by a transformer to a 100-ohm resistor inserted in the teleprinter line, and the circuit constants are of such values as to produce in the secondary winding of the transformer voltage impulses whose maximum amplitudes occur when the line current begins either to build up or to decay. These abrupt discontinuities marking off the second dimension, or time of duration, of the signal unit interval are always present in the line current waveform except on lines of exceptional length.

The essential circuit details of the teleprinter signal bias meter together with some waveforms of interest are shown in Figure 1; operation of the instrument is described now.

When placed in series with the teleprinter line between the central office apparatus and the remote teleprinter, any isolated spacing signal impulse produces steep-fronted voltage transients in the secondary of the coupling transformer driving the trigger tube *VT-1*. These waveforms are displayed at the upper right of the figure. By means of a switch, the correct anode of the dual-triode trigger tube is selected, and the grid of the relay drive tube *VT-2* is made subject to the swings in potential of this particular anode. In response to the corresponding changes in anode current of the relay drive tube, relay *RY-1* operates or releases coincident with the initial portions of the build-up or decay of the teleprinter line current.

Upon the decay of the line current, at the beginning of a spacing signal unit interval, relay *RY-1* is released and impresses positive battery potential on the previously de-energized 2-section time-delay network. After a delay equal to three-fourths of a normal-length unit interval, the junction of the network becomes energized and relay *RY-2* is operated. Operation of this relay removes the short circuit on capacitor *C-1* and prepares a path to negative battery for relay *RY-3* which remains unoperated since relay *RY-1* is still released. Capacitor *C-1* now begins to charge and the voltage on its upper terminal rises exponentially with time in a positive direction. It is this voltage that is to be compared, at the instant the teleprinter line is reclosed, to a predetermined normal voltage obtained from the bias potentiometer.

For a single unbiased spacing signal unit interval, the re-energization of relay *RY-1* will occur exactly 22 milliseconds after its release and the restoration of the armature of this relay to its front contact then will charge capacitor *C-2* through the operating winding of relay *RY-3* and the front contact of relay *RY-2*. Because the charging current to capacitor *C-2* is of extremely short duration, the contacts of relay *RY-3* close only momentarily, and at this instant the voltage across capacitor *C-1* is compared to the voltage at the potentiometer. In the presence of unbiased signals, the voltage across the capacitor will have an average value equal to the voltage obtained from the potentiometer when set for zero bias and there will be no energy transfer. If the teleprinter signals are biased to spacing, however, the spacing signal unit intervals will be longer than normal and re-energization of relay *RY-1* and the instant of comparison will take place when the voltage across capacitor *C-1* is greater than the voltage at the bias potentiometer. Under this condition

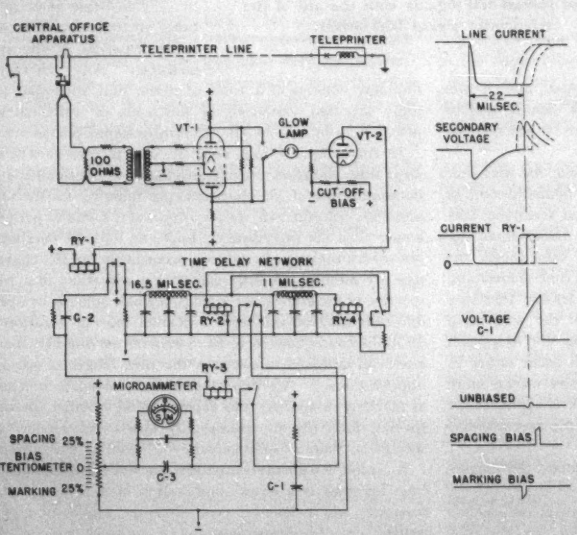

Figure 1. Theory of operation of the teleprinter signal bias meter

current will flow from capacitor *C-1* towards the potentiometer, and as a result of this current flow a charge will be stored on capacitor *C-3*. The successive increments of charge stored on capacitor *C-3*, one for each isolated spacing signal impulse, will be dissipated in the bias-indicating microammeter connected in shunt with this capacitor, and the meter will be deflected to the left to indicate a spacing bias. The deflections of the meter are damped by the resistive-capacitive network coupling the meter to capacitor *C-3* to eliminate what would otherwise be an objectionable susceptibility to sporadic unit intervals of different than average time length, but because the number of isolated spacing signal units arriving from time to time will vary with the intelligence transmitted, the magnitude of the microammeter deflection will, nevertheless, be variable and indeterminate. Now if the operating technician so wishes he may reduce the bias to zero by adjusting the bias control on the telegraph apparatus until the microammeter remains undisturbed at zero, or he may measure the magnitude of the signal bias by similarly nulling the microammeter by obtaining from the bias potentiometer a potential equal to that developed across capacitor *C-1* at the instant of comparison. The signal bias in per cent then is read off the calibrated dial of the potentiometer.

If the signals have a marking bias, the instant of comparison occurs early, and since the voltage across capacitor *C-1* is then less than normal the flow of current will be away from the potentiometer. Consequently, the increments of charge stored on capacitor *C-3* will be of the opposite polarity and the microammeter will deflect to the right.

To prevent a false indication from a spacing signal two or more units long, relay *RY-4* is arranged to remove the operating coil of relay *RY-2* from the network junction 11 milliseconds following its initial operation. The release of relay *RY-2* opens the operating circuit of comparison relay *RY-3* so that the ultimate re-energization of relay *RY-1* does not effect an unwanted voltage comparison.

For use by operating technicians, the components of the bias-measuring circuits just described have been assembled in the form shown in Figure 2. The complete assembly is 15 inches high and weighs 26 pounds. The bias potentiometer knob and scale are at the right of the sloping face of the instrument. Above the bias potentiometer is the signal polarity neon glow lamp coupling the trigger tube to the control grid of the relay drive tube. To be certain that the correct sense of the signal bias is indicated, the technician observes that this lamp remains on during a stop period in signal transmission; if it does not the switch below the potentiometer is thrown to the opposite position.

The four single-current relays used in the bias meter are of the mercury-wetted contact type and are not susceptible to adjustment. The small differences in the operating characteristics of individual relays necessitate recalibration of the meter following the replacement of a relay. Recalibration is done readily by nulling the bias meter on signals known to be unbiased and then rotating the scale slightly to coincide with the new zero.

A power polarity lamp, a neon glow lamp shunted by a rectifier, is located above the bias-indicating microammeter.

Figure 2. The teleprinter signal bias meter

This lamp glows steadily when the power-cord plug has been inserted correctly in a d-c 115–125-volt convenience outlet. The current consumption is 0.44 ampere.

Although this description has emphasized the monitoring of single-current or make-break teleprinter lines, in which service the teleprinter signal bias meter has already been received with great favor by operating personnel, the bias meter responds equally well when inserted in the polar current ring or dummy circuit of a telegraph network repeater system. In this strategic position, the operating technician is able to determine quickly if the separate teleprinter lines radiating from the hub are transmitting unbiased signals into the network and if not, to remove temporarily the offending leg from the network.

Answer to Electrical Essay

Three-Phase Network: The following is the author's answer to his previously published essay (*EE, July '51, p 623*).

The network impedance is expressed by the following matrix:[1]

$$Z=jX\begin{array}{c|ccc} & a & b & c \\ a & -1 & 1 & 1 \\ b & 1 & 1 & -1 \\ c & 1 & -1 & 1 \end{array}$$

Transforming it to symmetrical component reference axes, the following is obtained:

$$Z'=jX\begin{array}{c|ccc} & 0 & 1 & 2 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & -2 \\ 2 & 0 & -2 & 0 \end{array}$$

This illustrates the property of the network: "It will draw negative sequence current from a source of positive sequence voltage and vice versa."

REFERENCE

1. Tensor Analysis of Networks (book), **Gabriel Kron**. John Wiley and Sons, Inc., New York, N. Y. 1939, page 328.

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Cables for Vertical Risers

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VERTICAL RISER CABLE is used for power distribution systems over 100 feet in height, which might be found in tall buildings, mine shafts, and tunnels. It is distinguished from conventional cable by the need for incorporating in its design some method of supporting the weight of cable and insulation.

Four types of support are found in current practice. They are top-supported, type *A* by a galvanized steel wire armor, type *B* conductor-supported, and type *D* with added internal supporting members in the form of steel ropes. Type *C* is supported at regular intervals along the rise by clamps or grips external to the cable. This design permits the use of conventional cable design in tunnels where frequent support does not introduce any problem.

The common insulations, such as rubber, varnished cambric, and saturated paper, have been used with all the types mentioned. Rubber is used most commonly for voltages up to 15 kv, with varnished cambric as a close second choice. For higher voltages, saturated paper has been the usual selection, using either a special saturant which is semisolid below its rated operating temperature, or making provision for introducing oil at the top of the rise and periodically relieving static head pressure at the bottom. More recent installations have used special types of low gas pressure cables. With varnished cambric, the insulation is applied with a butt wrap instead of the usual overlap, and slipper compound is omitted or used sparingly to avoid oil leakage from the lower terminals.

Both lead and nonmetallic (rubber or neoprene) sheaths have been employed. Lead sheaths introduce no problem where cables are supported at short intervals throughout their length. For top-supported cables, the use of lead limits the safe length to 500 feet unless special precautions are taken to transfer the weight of the lead to the supporting armor uniformly along the length. Otherwise, the lead will slip or sag under the armor and accumulate in accordion-like wrinkles at the bottom of the run. The use of lead makes it difficult to obtain high safety factors for the top support of long lengths. In the case of rubber-insulated cables, present-day designs include a layer of conducting rubber or conducting fabric tape applied as internal or strand shielding over the conductor and vulcanized to the inner surface of the insulation. This avoids all internal electric discharges between conductor and insulation.

The electric power requirements of tall buildings are such that it is desirable to use a vertical a-c network for secondary distribution. Such a network requires high-voltage feed points for load centers at various levels, and vertical riser cables to service these load centers. The riser cables generally are installed in conduit and consequently are of the top-supported types. Type-*A* cable rated at 15 kv is the usual choice.

Modern mining methods are highly mechanized and electrically operated equipment predominates for underground workings. To avoid the use of cables in slopes and horizontal tunnels where they would occupy valuable space and be subject to injury from rock fall and mine equipment, it is desirable to feed the working faces from surface power lines through bore holes drilled vertically to the load centers. These bore-hole cables must of necessity be of the top-supported type. The usual a-c rating is 2,300 or 4,150 volts, although some of the larger mines are being forced to use higher voltages due to increasing power demands. Cables rated at 600 volts d-c are also common to supply power to haulage locomotives. Rubber insulation is used in the majority of cases, as bore holes are ordinarily wet. Type *B*, conductor support, is also very common, especially for the lower voltages and shorter runs. However, many mines use armored cable exclusively. Cables for mine shafts and working slopes are of the armored type of the same general construction as the armored bore hole cables, since such cables are liable to mechanical injury from falling objects, and generally they are clamped to the walls or shaft structure to keep them out of the way and to prevent swinging.

Methods of support for the armored types consist of clamps for the armor wire. Internal-type supporting members are supported through strain insulators and turnbuckles to the frame of the building. Special potheads are made for conductor-supported cables which provide both support and termination, or this type may be looped over strain insulators on a tripod over the bore hole. Supporting grips or clamps are used for continuous support at intervals, as in tunnels or shafts.

In general, each application has governing conditions which dictate the type which may be employed, and which determine the most practicable method of supporting the conductors so as to avoid slippage of the insulation. The problem of vertical transmission can be solved by one of several fundamental cable constructions as described. Cables built for horizontal performance should not be used thus without consideration of modifications required for the vertical components if over 100 feet of rise are encountered. It is necessary to provide fault protection, to avoid loss of support due to excessive burning, and expansion chambers at the bottom of the run to accomodate thermal and permanent stretch. With these precautions the operating experience on well-designed vertical riser cables compares favorably with other types.

Digest of paper 51-235, "Cables for Vertical Risers," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Toronto, Ontario, Canada, June 25–29, 1951. Scheduled for publication in AIEE *Transactions*, volume 70, 1951.

This article is presented as a report of the Special Purpose Cable Subcommittee of the AIEE Insulated Conductor Committee and represents data and conclusions furnished by members of that subcommittee.

W. T. Peirce is with the American Steel and Wire Company, Worcester, Mass.

INSTITUTE ACTIVITIES

Pacific Northwest Power Plants Will Be Inspected During Pacific General Meeting

Portland is famous as a host city to vacationers in the Pacific Northwest, and as an important center of commerce and industry; it is ideally situated in the center of vast hydroelectric installations and natural resources. Members of the Institute and their families should long remember the 1951 Pacific General Meeting to be held August 20–23. Headquarters for the meeting will be the Multnomah Hotel, near the center of the city, where arrangements have been made for a wide variety of technical sessions, social events, and entertainment. Reservations have been made for sufficient space for technical sessions and social events. A block of rooms has been reserved in the Multnomah and overflow reservations have been arranged for in adjacent hotels.

The "City of Roses" is easily accessible by all means of transportation. For those motoring to the meeting, there are numerous modern scenic highways leading through cool valleys and timber-covered mountains. The Oregon coast, Crater Lake, Columbia River Gorge, Oregon Caves, and Mt. Hood are only a few of the breath-taking sights to be seen. Major railroads and air lines serve the area.

TECHNICAL SESSIONS

The opening session Monday, August 20, will be presided over by C. B. Carpenter, who is Chairman of the General Committee. Dorothy McCollough Lee, Mayor of Portland, will deliver the welcoming address, and J. A. McDonald, Vice-President, District 9 of AIEE, will respond. Brigadier General O. E. Walsh, North Pacific Division Engineer, Corps of Engineers, United States Army, will speak on "The Relationship of Hydroelectric Power to Water Resource Development in the Columbia River Basin."

Monday afternoon the technical program will be inaugurated with sessions on Power, Industry, and Computing Devices.

Tuesday morning the program continues with interesting sessions on Transmission, Aluminum Industry, Cathodic Protection, and Aircraft Applications and Feedback Control Systems. In the afternoon, besides the Student Technical Papers, sessions are scheduled on Transformers and the Lumber, Pulp, and Paper Industry.

Wednesday, in the morning, technical papers on Transmission and Series Capacitors, Communication, and Instruments and Measurements will be held. In the afternoon the session on Transmission and Series Capacitors continues, along with a second session on Student Technical Papers, plus a new session on Electronic Power Converters.

Thursday morning, the last day of the meeting, will see sessions scheduled on Power, Carrier Current, and Electric Space Heating. In the afternoon the 1951 Pacific General Meeting will conclude with sessions on Switchgear, Instruments and Measurements, and Conductor Vibration.

INSPECTION TRIPS

The program includes a wide variety of inspection trips to highlight the industry and natural resources of the Pacific Northwest. All those attending will want to take fullest possible advantage of the trips to supplement the technical sessions as well as to view the beautiful scenery of the area while traveling to and from the sites. A nominal fee will be charged on most trips to cover transportation costs. Members are

(*Continued on page 707*)

Future AIEE Meetings

Pacific General Meeting
Multnomah Hotel, Portland, Oreg.
August 20–23, 1951
(*Final date for submitting papers—closed*)

AIEE Conference on Aircraft Equipment
Hollywood Roosevelt Hotel
Los Angeles, Calif.
October 8–10, 1951

AIEE Conference on Fractional Horsepower and Motor Applications to Refrigeration Equipment and Pumps
Dayton, Ohio
October 11–12, 1951

Fall General Meeting (*page 711*)
Hotel Cleveland, Cleveland, Ohio
October 22–26, 1951
(*Final date for submitting papers—closed*)

Joint AIEE-IRE Computer Conference
Benjamin Franklin Hotel, Philadelphia, Pa.
December 10–12, 1951

AIEE Conference on Electronic Instrumentation in Nucleonics and Medicine
Hotel Statler, New York, N. Y.
January 7–8, 1952

Winter General Meeting
Hotel Statler, New York, N. Y.
January 21–25, 1952
(*Final date for submitting papers—October 23*)

South West District Meeting
St. Louis, Mo.
April 15–17, 1952
(*Final date for submitting papers—January 16*)

North Eastern District Meeting
Binghamton, N. Y.
April 30–May 2, 1952
(*Final date for submitting papers—January 31*)

Summer General Meeting
Hotel Nicollet, Minneapolis, Minn.
June 23–27, 1952
(*Final date for submitting papers—March 25*)

Corps of Engineers' photo

One of the inspection trips will be to the McNary Dam construction. Shown here are the spillway bays, fish ladder, and the 675-foot-long navigation lock with the highest single lift, 92 feet, in the world

Tentative Technical Program

Pacific General Meeting, Portland, Oreg., August 20–23

Monday, August 20

10:30 a.m. Opening Session

Charles B. Carpenter, presiding

Address of Welcome: Mayor Dorothy McCollough Lee, Portland, Oreg.

Response to Welcome: J. A. McDonald, Vice-President, District 9.

Address: **The Relationship of Hydroelectric Power to Water Resource Development in the Columbia River Basin.** *Brig. General O. E. Walsh*, North Pacific Division Engineer, Corps of Engineers.

2:00 p.m. Power

CP. Electrical Features of Modern Automatic Hydro Stations.** *C. L. Gamble, A. G. Meller*, General Electric Company

51-287. Northwest Power Pool Interchange. *L. B. Cosgill*, Ebasco Services, Inc.

51-288. The Tracy Pumping Plant—Central Valley Project—California. *P. E. Richardson*, Bureau of Reclamation

51-289—ACO.* Rotating Amplifiers for Control of Bus Voltage Fluctuation. *C. L. Sidney*, Southern California Edison Company; *Jack W. Savage*, Westinghouse Electric Corporation

51-290. Grounding Effectiveness at Grand Coulee 230-Kv Switchyards Verified by Staged Fault Tests. *A. C. Conger, R. K. Seely, W. H. Clagett*, Bureau of Reclamation

2:00 p.m. Industry

CP. Conversion of the Facilities of Geneva Steel Company to Peacetime Operations.** *M. E. Strate*, Geneva Steel Company

CP. Kilowatts and Atomic Energy.** *H. A. Carlberg*, General Electric Company

CP. The Pend Oreille Mines and Metal Company Conveyor System.** *N. H. Rayner*, Pend Oreille Mines and Metal Company

CP. Development in Variable Speed Pumping Units.** *T. B. Hayes*, Cornell, Howland, Hayes and Merryfield

CP. The 480-Volt Delta System—Grounded or Ungrounded.** *C. B. Wagner*, General Electric Company

CP. The Application and Characteristics of Selenium Rectifier in a Cottrell Precipitation System.** *D. R. Allsop, D. R. Hoopes*, Westinghouse Electric Corporation

2:00 p.m. Computing Devices and Methods

CP. Applications of a Mechanical Differential Analyzer to Electrical Engineering.** *Earl Jansson, Don Lebell*, University of California at Los Angeles

CP. The Rayleigh Method in Network Calculations.** *F. W. Schott, J. Hoilfron*, University of California at Los Angeles

51-291. The Use of High Speed Relays in Electric Analogue Computers. *R. R. Bennett, A. S. Fulton*, Hughes Aircraft Company

CP. Operational Experience with the SWAC.** *H. D. Huskey*, Bureau of Standards

CP. The MADDIDA 44A Computer.** *C. B Dennis*, Northrup Aircraft, Inc.

Tuesday, August 21

9:30 a.m. Transmission

CP. Higher Transmission Voltages, Developments and Trends.** *P. L. Bellaschi*, Consulting Engineer

51-292—ACO.* Experiences with 230 Kv on the System of the Bonneville Power Administration. *A. A. Ostrowiak, H. L. Rorden*, Bonneville Power Administration

51-293. Cable Through Tunnel Under Continental Divide Links Power Systems. *F. M. Wilson, R. A. Nelson*, Bureau of Reclamation

51-294. Incremental Method for Sag-Tension Calculations. *Maurice Landau*, Department of Water and Power, The City of Los Angeles

9:30 a.m. Industry—Chemical, Electrochemical, and Electrothermal

CP. Historical Review of Power Supplies for the Aluminum Industry.** *Waldo Porter*, Aluminum Company of America

CP. Electrical Installations in an Aluminum Plant.** *G. B. Scher*, Kaiser Engineers, Inc.

CP. Cathodic Protection of Stainless Steel Buried in the Ground.** *F. J. Molleruz, J. F. Kane*, General Electric Company

CP. Economics of Cathodic Protection.** *R. M. Wainwright*, University of Illinois

9:30 a.m. Aircraft Applications and Feedback Control Systems

51-295. Steady-State Characteristics of Carbon-Pile Voltage Regulators. *D. G. Seorgis, D. H. Schaefer*, Naval Research Laboratory

51-296. Design of Permanent Magnet Alternators. *R. M. Saunders, R. H. Weakley*, University of California

51-297. Servomechanism Characteristics of D-C Motor Driven by Controlled Rectifiers. *L. D. Harris*, University of Utah

51-298—ACO.* Transformation of Block Diagram Networks. *T. D. Graybeal*, University of California

—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

2:00 p.m. Transformers

CP. Transformer Tests as Related to the New Basic Impulse Levels.** *G. W. Clothier*, Allis-Chalmers Manufacturing Company

51-299. Audio Noise of Power Transformers in Residential Areas. *A. V. Lambert*, Portland General Electric Company

51-300. Some Methods of Obtaining Correct Line-Drop Compensation on Single-Phase Voltage Regulators Used on 3-Phase Systems. *H. L. Prewett*, Westinghouse Electric Corporation

CP. Performance of a Mobile Oil Refinery.** *D. L. Brown*, Portland General Electric Company

2:00 p.m. Industry—Pulp and Paper, Lumber

51-301. Protection of Electric Equipment Against Corrosion in Industrial Plants. *H. E. Springer* Rayonier, Inc.

CP. Motor Application in the Pulp and Paper Industry.** *Don Platt*, Crown-Zellerbach Corporation; *J. A. Tudor*, Westinghouse Electric Corporation.

51-302. Handling Logs by Electric Motocylinders. *H. A. Rose*, Westinghouse Electric Corporation

CP. Amplidyne-Controlled Veneer Lathe Drive.** *W. D. Vincent, Fred Thompson*, General Electric Company

CP. Electric Log-Carriage Drives.** *T. M. Greer, H. A. Rose*, Westinghouse Electric Corporation

2:00 p.m. Student Technical Papers

Wednesday, August 22

9:30 a.m. Transmission and Series Capacitors

51-303—ACO.* Functional Requirements of Series Capacitors in Long Distance Transmission Lines and a Description of Fundamental Features of the Installation in the Bonneville Power Administration System. *Alexander Daujikov*, Bonneville Power Administration; *E. C. Starr*, Oregon State College

51-304. A 24,000-Kvar Series Capacitor in a 230-Kv Transmission Line. *R. E. Marbury, F. D. Johnson*, Westinghouse Electric Corporation

51-305. Series Capacitors During Faults and Reclosing. *E. L. Harder, J. E. Barkle, R. W. Ferguson*, Westinghouse Electric Corporation

51-306. Development of Corona Measurements and Their Relation to the Dielectric Strength of Capacitors. *R. J. Hopkins, T. R. Walters, M. E. Scoville*, General Electric Company

9:30 a.m. Communication

CP. The N1 Carrier System.** *P. G. Edwards*, Bell Telephone Laboratories, Inc.

CP. Radio Relay Graduates to Nation Wide Service.** *D. I. Cone*, Pacific Telephone and Telegraph Company

CP. The Co-ordinated Communication System of the Bonneville Power Administration.** *A. W. Adams*, Bonneville Power Administration

CP. Communication Requirements for Civil Defense.** *B. J. Willingham*, General Electric Company

9:30 a.m. Instruments and Measurements

CP. A Fast Response Electronic Telemetering System.** *Carl Oman*, Westinghouse Electric Corporation

CP. Performance Characteristics of High Speed Telemetering Systems.** *J. I. Holbeck*, Bonneville Power Administration

CP. Overload Protection of Alternating Current Instruments.** *Wilson Pritchett, Elazar Tron*, University of California

* ACO: Advance copies only available; not intended for publication in *Transactions*.

** CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

51-308. The Accuracy of Current Transformers Adjacent to High Current Busses. *R. A. Pfuntner*, General Electric Company

CP. Mutual Reactors for Bus Differential Protection.** *Francis Irish*, Central Arizona Light and Power Company; *Robert Hartley*, Westinghouse Electric Corporation

2:00 p.m. Transmission and Series Capacitors

CP. Developments and Experience with Series Capacitors in Sweden.** *G. Jancke, K. F. Åkerström*, Swedish State Power Board

51-309. Economic Aspects of Series Capacitors in High-Voltage Transmission. *E. C. Starr*, Oregon State College; *R. S. Seymour*, Bonneville Power Administration

51-310—ACO.* 230-Kv Series Capacitor Tests. *C. C. Diamond, E. J. Harrington, J. R. Curtis*, Bonneville Power Administration

51-311—ACO.* Transmission-Line Terminal-Voltage-Ratio for Best Economy. *H. M. Rustebakke*, University of Washington

2:00 p.m. Electronic Power Converters

CP. A Method of Load Control for an Aluminum Reduction Plant.** *L. H. Wolgast*, Reynolds Metal Company

CP. A Discussion of Corrosion Problems in Rectifier Cooling Systems.** *S. J. Pope*, Kaiser Aluminum Company

CP. A Discussion of Some of the Factors Involved in Ignitor Erosion.** *Waldo Porter*, Aluminum Company of America

CP. A Trial of Resonance Shunts to Reduce Rectifier Harmonics in A-C Supply Lines.** *L. A. Carter*, Pacific Power and Light Company; *D. A. Rischel*, Pacific Telephone and Telegraph Company

CP. Ignitron Rectifier Locomotive.** *W. A. Brecht*, Westinghouse Electric Corporation

2:00 p.m. Student Technical Papers

Thursday, August 23

9:30 a.m. Power

CP. Electrical Features of Pacific Gas and Electric Company Contra Costa Steam Plant.** *Melvin Lewis*, Bechtel Corporation

CP. The Gadsby Steam Plant.** *E. M. Naughton*, Utah Power and Light Company

CP. Operation of Steam Generating Station Auxiliaries at Subnormal Speed.** *H. C. Austin*, Southern California Edison Company

CP. Atomic Energy and the Role of the Electrical Engineer.** *W. J. Dennis*, General Electric Company

9:30 a.m. Carrier Current and Microwave

CP. Carrier or Microwave for System Relaying.** *T. M. Morong*, Salt River Power District, Arizona; *K. V. Fletcher*, General Electric Company

CP. Operating Experience of Supervisory and Telemetering over 960-Megacycle Link.** *T. A. Phillips*, Central Arizona Light and Power Company

CP. Microwave System Design for Utilities.** *C. M. Backer*, Philco Corporation

CP. Application of a Microwave Radio Link by Bonneville Power Administration.** *S. Metzger, N. Gottfried, R. Hughes*, Federal Telecommunications Laboratories, Inc.

51-312. Traveling Wave Relations Applicable to Power-System Fault Locators. *L. J. Lewis*, University of Washington

9:30 a.m. Electric Space Heating

CP. Electric Space Heating Distribution Costs.** *O. D. Hurd*, Benton County Public Utility District

CP. Heat Pump Operating Costs for the Equitable Building.** *J. D. Kroeker*, Consulting Engineer

2:00 p.m. Switchgear

51-313. Resistance Effect on 230-Kv Fault Values Relating to Circuit Breaker Application at Grand Coulee. *A. C. Conger*, Bureau of Reclamation

51-314. New Design Oil Circuit Breaker for 7,500,000-Kva 230-Kv Service. *F. B. Johnson, R. E. Friedrich*, Westinghouse Electric Corporation

51-315. High-Voltage Interrupter Switch Applications. *A. C. Schwager*, Schwager-Wood Corporation

51-316. Switching of Large Shunt Capacitor Banks for 15-Kv Service by Compressed Air Circuit Breakers. *B. P. Baker*, Westinghouse Electric Corporation

CP. Heavy-Duty High-Voltage Dead-Tank Circuit Breaker.** *D.M.Umphrey*, Pacific Electric Manufacturing Corporation

2:00 p.m. Instruments and Measurements

51-317—ACO.* Automatic Amplifying and Recording System for a Mass Spectrometer. *P. S. Goodwin, R. L. Sink*, Consolidated Engineering Corporation

51-318. Electrostatic Radiation Monitors. *J. R. Bradburn, A. A. Lahti*, Consolidated Engineering Corporation

51-307. A Magnetic Fluid Dynamometer. *D. W. Brede*, University of California

2:00 p.m. Conductor Vibration

CP. Analysis of Conductor Vibration.** *R. H. Nau*, University of Illinois

CP. An Analysis of Conductor Vibration Field Data.** *R. F. Steidel, Jr.*, Oregon State College; *M. B. Elton*, Bonneville Power Administration

CP. Damped and Undamped Vibration Characteristics of Type H H Copper Conductor.** *Bernard Fried, M. A. Gutzer*, Washington State College

CP. Analysis of Wind-Induced Dynamic Stresses Observed in Field Tests.** *Bernard Fried, A. T. Hard*, Washington State College

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(*Continued from page 705*)

urged to sign up for the trips during registration as certain trips will be limited as to attendance. For security reasons, proof of citizenship will be required on several of the visitations as indicated in the descriptions following.

Bonneville Power Administration's J. D. Ross Substation, Vancouver, Wash. (Monday 1:30 p.m.–4:30 p.m.). The J. D. Ross substation is a large modern transformation substation located a short distance from the northern city limits of Vancouver, Wash. It is the termination of two 230-kv lines from Bonneville Dam, where a tie-in is made with lines from Grand Coulee Dam, and of a single 230-kv line north to the Puget Sound area. Two 35,000-kva synchronous condensers and a 20,000-reactive-kva bank of shunt capacitors are used for reactive control. The southern terminus of the Ross-Snohomish microwave system is located here and may be inspected. The load dispatching for the entire Bonneville Power Administration system also is conducted here, and the new dispatching board may be seen.

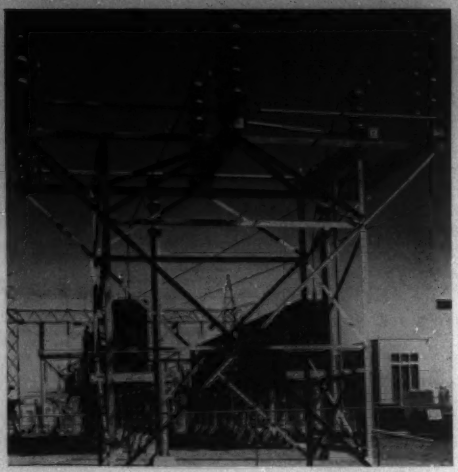
McNary Dam (Tuesday air flights—and Friday). The Corps of Engineers, United States Army, has this large structure well under way. It is located 190 driving miles east of Portland on United States Highway 730. Air flights will be conducted Tuesday over the Columbia River Gorge to view this construction which was started in 1948. Majestic Mt. Hood and other snow-capped peaks of the Cascade range will provide a long-to-be-remembered panorama. For those returning east by auto, or wishing to drive to the site, arrangements have been made for this "land" inspection on Friday. Ultimate installed capacity of 14 units will be 980,000 kw. The navigation lock will be the highest single lift lock, 92 feet, in the world. McNary Dam is located 292 miles above the mouth of the Columbia River and its reservoir will provide slack water navigation for 67 miles into the Columbia and lower Snake Rivers. A fish ladder is provided for on both the Oregon and Washington shores to preserve the migratory fish, including the famed Columbia River salmon. The reservoir which will be created will lower water pumping costs and make feasible the irrigation of approximately 400,000 acres of land. Proof of citizenship will be required of those making the "land" inspection.

Oregon State Highway Commission photo

The Vista House at Crown Point on the Columbia River Highway provides an unusual vantage point from which to view the Columbia River coursing its way through the Cascade Mountains between Washington and Oregon. The Vista House is more than 700 feet above the river

Aluminum Company of America, Vancouver, Wash. (Tuesday 1:30 p.m.–5:00 p.m.). The modern 175,000-kw mercury-arc rectifier station, fabricating plant, rod mill, wire mill, and cable manufacturing equipment will be shown. Here is an opportunity to see one of the Pacific Northwest's mushrooming industries which reduces the raw material to the finished product. Cheap electric power has made possible the large industrial expansion of the area. Proof of citizenship will be required for this trip.

Crown-Zellerbach Corporation, Camas, Wash. (Wednesday 8:30 a.m.–12 noon). Here will be seen large logs converted into facial tissue. Those attending will view the woodmill where logs start their journey by being chipped; the paper machine room where various grades of paper are produced



A 230-kv series capacitor installation at the Chehalis, Wash., Substation, Bonneville Power Administration, will be seen on an inspection trip

from heavy wraps to fine tissue; the bleach plant where sulphite and sulphate pulps are bleached to the desired whiteness; the converting plants where napkins, toilet tissue, facial tissue, and so forth, are converted and packaged; and the bag factory for producing any bag commercially used. Another interesting equipment to be seen is the electronic control on one of the paper machines as well as the steam plant with a new high-pressure boiler. Proof of citizenship may be required.

Bonneville Dam and Powerhouse (Wednesday, 1:30 p.m.–5:00 p.m.). Located approximately 50 miles east of Portland in the beautiful Columbia River Gorge, Bonneville Dam harnesses the river for a total rated output of 518,400 kw from ten generators. This was the first of several projected Federal hydroelectric projects to be combined in furnishing the Pacific Northwest empire with abundant electric power. The dam has created a 50-mile lake and its navigation lock is presently the largest single-lift lock in the world, making possible ocean ship navigation to The Dalles, Oregon, which is 200 miles inland from the Pacific Ocean. The world-renowned Columbia River salmon runs are passed over this dam by a huge fish ladder or stairway over a mile long and also by electrically operated fish elevators. Proof of citizenship will be required.

Weyerhaeuser Timber Company, Longview, Wash. (Thursday—all day). This is the world's largest wood processing center. Here the log can be followed through the mill to the finished lumber and plywood. Among the machines in the operation is the hydraulic log barker where powerful jets of water tear the bark from rotated logs. The sawmill, planing mill, Presto-Log Plant, and plywood plant will be among the operations to be seen. Proof of citizenship may be required.

Bonneville Power Administration, Chehalis, Wash., Substation (Thursday—all day). This station is located approximately 100 miles north of Portland and is the only installation of 230-kv series capacitors in America. There are also 35,000 reactive kva of 13.8-kv shunt capacitors, several high-speed 230-kv 20-cycle reclosing oil circuit breakers, and several types of phase-comparison carrier relays.

Equitable Building, Portland (Thursday 1:30 p.m.–5:00 p.m.). The nation's largest heat pump installation is in the newly constructed 12-story Equitable Building. Completely air-conditioned, this aluminum-clad double-glazed window building is an engineering and architectural showplace where heat or cold from the earth is electrically pumped into the building to maintain year-round comfort.

Pacific Power and Light Company's Yale and Merwin Hydroelectric Developments (Friday—all day). Private power in the Northwest is a large contributor to the vast interconnected power pool. The Merwin project has an output of 112,500 kva from two generators, while the Yale development, which is under construction, will add 108,000 kw from its two units by 1952. Attendance on this trip will be limited, so reservations should be made as soon as possible following arrival.

Oregon State College, Corvallis, Oreg., *United States Department of the Interior Bureau of Mines*, and *M and M Woodworking Company*, Albany, Oreg. (Friday—all day). AIEE President F. O. McMillan's own home town and school will be visited here. Oregon State College's newly completed electrical engineering building, Dearborn Hall, will be seen, as well as the college's beautiful campus. During the return trip to Portland in the afternoon, a stop will be made at Albany to tour the Northwest Electrodevelopment Laboratory of the United States Bureau of Mines, where extensive electrometallurgical research is conducted. One outstanding project here is a method developed for the production of ductile zirconium. Research and investigations of other processes and metals are supplemented with petrographic, metallographic, X-ray, spectrographic, and chemical laboratories and full shop facilities. From here the group will visit the M and M Woodworking Company where the manufacture of plywood can be viewed from the log to the finished product. Of special interest will be electronic heating where 600 kw of radio frequency is used in curing the plywood's glue. The trip to Corvallis will be made via highway 99W through McMinnville while the return trip will be via 99E and the cities of Albany, Salem, and Oregon City.

Portland General Electric and Pacific Power and Light Company Steam Plants and Substations (Times as arranged by individuals with these utilities). Modern substations and practices can be viewed. Among the many points of interest will be Pacific Power and Light Company's treatment of objectionable substation noise (see April 1951 issue of *Electrical Engineering*, page 325).

LADIES' EVENTS

The Spruce room in the Multnomah Hotel has been reserved as the ladies' headquarters. At all times there will be hostesses present to extend a welcome. Here the ladies may have a place to get acquainted and to seek information.

Monday, August 20. From 2:30 p.m. to 4:30 p.m. a reception for President F. O. McMillan's wife and the wives of the Board of Directors in the form of a get-acquainted tea will be held in the Portland Art Museum, and all the ladies are cordially invited to attend. Musical entertainment will be provided as well as conducted tours through the museum. The Portland Art Museum is one of the newer, more beautiful buildings in Portland. Since its inception in 1892 it has been an important factor in Portland's cultural life. Among the many exhibits, those of Indian Art of the Northwest will show the imagination and craftsmanship which make this display unique and will prove of interest to those attending.

Tuesday, August 21. Starting in the morning, a trip will be made to the Sanctuary of Our Sorrowful Mother. Here you will find the serene and enchanting beauty of a monastery garden. Continuing up the newly completed waterlevel or express route of the Columbia River Highway, the group will stop for refreshments at the well-known Multnomah Falls which drops 620 feet down the wall of the Columbia Gorge in a misty recess of green moss and delicate ferns. The return trip will be made via the scenic route, passing numerous waterfalls and other beautiful scenery.

Wednesday, August 22. A chartered bus will take the group to the Columbia Edgewater Country Club for luncheon and an afternoon of entertainment. Numerous prizes and surprises are scheduled.

Thursday, August 23. Should there be sufficient interest expressed in a trip to Timberline Lodge and Mt. Hood, this trip has been tentatively scheduled for Thursday.

STUDENT ACTIVITIES

Students will be most welcome to attend the meeting, and time has been scheduled

on Tuesday and Wednesday afternoons for presentation of their technical papers. In addition, there will be one Student delegate meeting, a Branch Counselor's meeting, and a dinner meeting for the Students and Counselors.

SOCIAL EVENTS

The evenings during the meeting have been left free of technical sessions in order that visitors might take full advantage of the entertainment being planned. The reception for the Portland Section's own AIEE President Fred O. McMillan has been scheduled for Tuesday evening, followed by special movies of a scenic nature. Wednesday evening will be highlighted by the banquet and dance at the Multnomah Hotel.

SPORTS

Golf has been arranged for the members and their guests. The annual golf tournament for the J. B. Fisken cup will be held at the Alderwood golf club on Tuesday, August 21. Entries should be registered at the Sports Information Desk. Transportation will be arranged by the Sports Committee from the Multnomah Hotel to the golf club, and play will begin immediately after lunch. Locker space, some rental clubs, and refreshments will be available at the club. Each player registering should register his handicap based on the average of scores made on his regular course. This average and the club's par must be turned in at the time of registration, and the handicap will be computed in accordance with the "National Handicap Table." This handicap will be used for medal play. The J. B. Fisken trophy will be presented to the AIEE member with the lowest net medal play. There will be other prizes awarded for players with low gross and low net scores. Portland is noted for its beautiful golf courses. Alderwood Golf Course, which is being used for the tournament, is one of the finest in the area, but there are also many others equally as beautiful. Arrangements may be made for noncompetitive play on many of these courses.

HOTEL ACCOMMODATIONS

Rooms have been set aside at the Multnomah Hotel and other hostelries. Sleeping rooms at the headquarters hotel are limited, but sufficient space has been promised for AIEE requirements. Early reservations will be advantageous and should be made through the hotel committee in accordance with the convention housing policy of the Portland Hotels. Advance registration should be made to Mr. C. L. Brown, Chairman, Hotel Committee, c/o Pacific Power and Light Company, Public Service Building, 920 S.W. 6th Avenue, Portland 4, Oregon. All requests should specify type of accommodations, number and names of persons, date and time of arrival, and date of departure.

A schedule of typical room rates, all with baths, is given here.

Housing policy	
Single room	not listed under Portland Hotels
Double rooms with double bed	$ 5.50 to $10.00
Double rooms, twin beds	6.00 to 14.00
Deluxe doubles	11.00
One bedroom suite	20.00 to 25.00
Deluxe twin and double connecting	18.00

Hotels will bill a flat fee of $5.00 for unclaimed reservations not cancelled in sufficient time to assure rerental.

PACIFIC GENERAL MEETING COMMITTEE

The members of the Pacific General Meeting Committee are: C. B. Carpenter, *Chairman;* M. M. Ewell, *Vice-Chairman;* D. A. Riechel, *Secretary;* F. O. McMillan, *AIEE President;* J. A. McDonald, *Vice-President;* H. E. Arnett, *Chairman, Portland Section;* W. E. Enns, *Technical Programs;* D. L. Brown, *Registration;* C. L. Brown, *Hotels;* A. O. Mangold, *Finance and Treasurer;* O. A. Demuth, *Inspection Trips;* M. G. Poland, *Transportation;* M. D. Duffy, *Entertainment;* R. B. Temple, *Students;* W. Porter, *Sports;* Mrs. M. M. Ewell, *Ladies;* and R. R. Bacchi, *Publicity.*

New Membership Requirements

As announced at the Annual Meeting in Toronto on June 25, the proposed amendments to the Constitution have been approved by ballot of the membership and, in accordance with Section 69 of the Constitution, the new provisions go into effect 30 days after the Annual Meeting—or July 25, 1951.

Any applications for membership or change of grade made after July 25 must be made on new forms. It is necessary therefore that the forms previously in use be discarded and new ones obtained from AIEE headquarters or Section Membership or Transfer Committees. Any applications received on the now obsolete forms will be returned to the applicant along with information regarding the new requirements and a new form.

AIEE Fall General Meeting to Feature Address by Dr. T. K. Glennan of AEC

A highlight of the AIEE Fall General Meeting in Cleveland, Ohio, will be an address, on October 22, by Dr. T. K. Glennan, of the Atomic Energy Commission (AEC). Doctor Glennan, on leave of absence from the presidency of Case Institute of Technology, won the respect of the people of Cleveland for his ability to get things done during his two years at Case, prior to his appointment by President Truman to the AEC. The subject of his talk at the meeting will be given later.

INSPECTION TRIPS

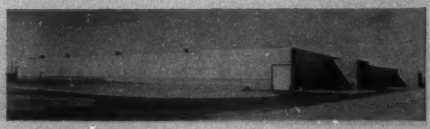
Outstanding among a number of inspection trips planned for the Fall General Meeting is a visit to the new Lincoln Electric plant in nearby Euclid, Ohio. This $9,000,000 plant, built expressly for the manufacture of welding equipment, is as revolutionary and progressive in its design as Mr. James Lincoln's internationally recognized ideas on industrial relations. The plant layout has been planned to eliminate most material handling problems and to use a visual inventory system. The manufactured product moves on production lines that are actually straight from the materials receiving department to the finished product shipping department.

Novel arrangement provides for production and executive managers to be adjacent to their respective manufacturing areas. Employees enter and leave the building by way of a central tunnel running under the main production floor. Stairways are arranged so that any worker may reach the main floor within 200 feet of his workplace.

The plant has no windows, and the outer walls are of bright-surfaced aluminum sheet. Features of the air-conditioning and artificial lighting systems are entirely in accord with the other ultra-modern aspects of the plant design. Three years of intensive planning and designing were required in order to develop the plant layout which promises to be one of the world's most efficient manufacturing plants.

As a leading steel-producing center, Cleveland is the home of several modern steel mills. One of these, The Republic Steel Company, will be an inspection trip site during the meeting. This company has a completely integrated operation performing all of the functions of steel making from coke ovens and blast furnaces to finishing mills. In addition to plate, rod, and bar mills, Republic operates a 98-inch strip mill which is the first of its kind in the world. AIEE members will witness many of the spectacular operations of steel making on this trip in addition to observing electrical installations operating in exacting service.

Among other inspection trips definitely approved for the Fall General Meeting are visits to Reliance Electric & Engineering Company, the Clark Controller Company, Goodyear Tire and Rubber Company at Akron, Ohio, and Nela Park of the General Electric Company. Several other trips, one to the NACA Lewis Flight Propulsion



An outstanding inspection trip during the Fall General Meeting will be a visit to the new Lincoln Electric Plant in Euclid, Ohio

Laboratory and another to the Cadillac Tank Plant, have tentative approval, pending the considerations of defense security.

HOTEL ACCOMMODATIONS

The Hotel Cleveland will be the meeting and technical sessions' headquarters. Rooms will be available at the Cleveland as well as at the Statler, Carter, Allerton, and the Hollenden Hotels in downtown Cleveland. Reservations may be made through the Hotel Cleveland, or by contacting any of the other hotels directly. A complete listing of hotel information will be sent to Institute members later, giving rates, accommodations, and application blanks.

U. S.—Canadian Relationship Stressed at Summer General Meeting in Toronto

The 67th Annual Summer General Meeting of the AIEE, which was held at the Royal York Hotel, Toronto, Canada, June 25–29, 1951, had an international aspect with an attendance of 1,851, an all-time record for Summer General Meetings. Members and guests were from all parts of the United States and Canada as well as from India, England, and Mexico.

ANNUAL MEETING

The Annual Meeting of the AIEE was opened by a brief ceremony: the General Committee Chairman, O. W. Titus, and his committee members led the Institute officers to the platform to the skirl of bagpipes. After welcoming the guests to Toronto, Mr. Titus turned the meeting over to AIEE President T. G. LeClair. The first order of business was a condensed report of the Board of Directors by AIEE Secretary H. H. Henline. (See pages 724–50 of this issue for the complete report.) The duties of the Vice-Presidents are to be extended in order to relieve the president of so much traveling. The AIEE membership as of June 1951 had grown to 39,683; and during the past fiscal year ending April 30, 1951, the membership had increased by 3,860. In the treasurer's report, W. I. Slichter said that in the past year the finances of the Institute were the healthiest they had been in several years.

President LeClair then explained the constitutional changes on which the members had voted in the past year and Secretary Henline read the results of the Committee of Tellers. The constitutional amendment adding the grade of Affiliate member was carried by a vote of 15,076 to 1,264. The amendment transferring membership dues requirements from the Constitution to the By-Laws was also passed by a vote of 13,026 to 3,278. President LeClair declared these changes are now effective.

The Report of the Committee of Tellers, which announced the election of the following AIEE officers, was also presented by Secretary Henline: for President, F. O. McMillan; for Vice-Presidents, J. C. Strasbourger, J. D. Harper, F. W. Norris, N. M. Lovell, and W. R. Way; for Directors, F. R. Benedict, R. F. Danner, and D. D. Ewing; for Treasurer, W. I. Slichter. At this point President LeClair presented the president's badge to President-elect F. O. McMillan, who thanked the members and outlined some of his objectives. (See pages 657–59 of this issue for his address.)

After a brief intermission President LeClair introduced A. H. Kehoe, Chairman of the Lamme Medal Committee, who gave a short history of the establishment of the medal; T. D. Jolly, who told of the career of the medalist; and Donald I. Bohn, chief electrical engineer, the Aluminum Company of America, to whom President LeClair presented the gold medal. Mr. Bohn's response and the other addresses pertaining to the Lamme medal may be found on pages 663–66 of this issue.

The concluding address of the meeting, "The Power to Progress," was given by President LeClair. The full text of this presentation will be found on pages 563–565 of *Electrical Engineering* for July.

The initial social event of the Summer General Meeting was the Opening Luncheon, which followed the Annual Meeting. A. H. Frampton, Vice-President of District 10, after welcoming the guests to Toronto, presented keys of the city to President LeClair and Secretary Henline. Mr. Frampton then introduced City Comptroller Saunders of Toronto, who extended Canada's welcome to the visiting members. After these brief ceremonies Don Henshaw, a prominent figure in Canadian radio circles, told about United States—Canadian relations and how the other countries of the world should take note of the mutual trust and friendship between our two countries, whose boundaries have no armed guards.

INSPECTION TRIPS

As usual, a popular feature of the Summer General Meeting was the varied schedule of inspection trips, which ranged from the trip through the new underground subway being constructed in downtown Toronto to the University of Toronto's David Dunlap Observatory.

Probably the most interesting inspection trip was through the Toronto Transportation Commission's subway, which was followed by an inspection trip to the Hillcrest Shops, noted for their electrical maintenance and repair facilities on Toronto's 1,700 transportation units. Other trips were to the Bell Telephone Elgin Building, several electrical manufacturing plants, and Niagara Falls and the Welland Canal.

ENTERTAINMENT

The major social function of the Summer General Meeting, the dinner dance, was held in the Banquet Hall of the Royal York Hotel on Thursday evening. The dinner address was delivered by Principal and Vice-Chancellor Robert C. Wallace of Queen's University, Kingston, Ontario. He was introduced to the diners by O. W. Titus, the toastmaster.

Mr. Wallace stated that the 14,000,000 population of Canada has a world-wide interest because it is part of a world-wide commonwealth. Canada is a vast source of untapped power, and although great engineering feats are being accomplished much remains to be done. The large number of things we of the United States have in common with Canada is a step toward peace—this friendship should be an example to all the countries of the world. Patience must be exercised as it takes a long time for international understanding to become effective. The speaker told how Canada is undergoing industrial development, but like those things we remember today about the ancient Greeks—their cultural attainments—we should not neglect those aspects today in

Incoming President McMillan is discussing his objectives for the coming year with President T. G. LeClair during the Summer General Meeting

our educational schedules emphasizing the practical matters which are so seemingly important.

Following the banquet, dancing was enjoyed by the members and their guests in the Concert Hall of the Royal York Hotel. During the intermission an all too-short recital was given by the all-girl choir, the Leslie Bell Singers, who sang some typical Canadian songs.

On Monday evening an English buffet-style dinner was served after which President LeClair and his party were "piped" to a reception line in one of the parlors from which the guests went to the Concert Hall where dancing was enjoyed until 1.00 a.m.

On Tuesday evening entertainment of the open-house variety was held at Hart House on the campus of the University of Toronto. Guests were welcomed by a carillon recital, followed by a stage show under the direction of Mavor Moore of the Canadian Broadcasting Company. Guests could choose between ballroom dancing in the gymnasium or square dancing in another room.

On Wednesday evening members were invited to a salon of color photography under the care of the Toronto Camera Club, where colored slides were shown, followed by a colored motion picture, "Loon's Necklace," based on the folk-lore of Canada's west coast Indians.

SPORTS

Prizes for the athletic events held during the Summer General Meeting were awarded at a Friday noon luncheon by D. L. Brazier, Chairman of the Sports Committee, who was introduced by the toastmaster, O. W. Titus.

The Mershon Golf Trophy was won this year by W. R. Hough of Cleveland, Ohio. Others who obtained low scores were H. A. Glover, Melrose Park, Ill., low net runner up; C. B. Oler, Annapolis, Md., low gross; G. R. Canning, Cleveland, Ohio, low net, first flight; R. L. Mooney, Toronto, Ontario, Canada, low net, second flight; G. N. Brown, New York, N. Y., low net, third flight. R. A. Boyd, Montreal, Quebec, Canada, took the hidden hole award, and Mrs. D. Lewis, the only lady player (not eligible for the tournament) was honored as the Most Inspirational Golfer.

In the tennis competition, the Mershon trophy was won by B. W. Storer, Chicago, Ill., with J. Leeming, Toronto, Ontario, Canada, as runner up. Doubles were won by H. J. Wilkinson and Tom Henry, Jr., both of Toronto, Ontario, Canada; and runners up were H. M. Ellis and E. F. Connolly, also of Toronto.

COMMITTEE

Members of the General Committee, whose planning was responsible for the great success of the Toronto meeting, included the following: O. W. Titus, *Chairman;* W. R. Harmer, *Vice-Chairman;* J. T. Fisher, *Secretary;* M. Fraresso, *Hotels;* M. J. McHenry, *Finance;* J. H. Smith, *Ladies' Entertainment;* P. J. Croft, *Entertainment;* R. J. Brown, *Publicity;* W. J. Gilson, *Meetings and Papers;* J. G. Inglis, *Transportation;* G. A. Brace, *Inspection Trips;* M. C. Thurling, *Treasurer;* D. C. Brazier, *Sports;* D. G. Geiger and J. T. Thwaites, *Members at Large;* and A. H. Frampton, *Vice-President, District 10.*

Conference of AIEE Section Delegates Held During Summer General Meeting in Toronto

On Tuesday morning the conference of delegates from the AIEE sections was held, over which D. I. Anzini, Chairman of the Sections Committee, presided and at which F. S. Benson was secretary. The meeting was held in the Royal York Hotel.

Mr. Anzini, after introducing C. S. Purnell of the New York Section as the next Sections Committee Chairman, invited President-elect McMillan to say a few words. He dealt with student activities: the two-dollar increase to five dollars in student enrollment fees will benefit this group as there will be increased activities made possible at the various branches. A great problem is that only approximately one-third of the potential number of graduates enroll as members. Enrolled Student Members should be encouraged to attend Section meetings so that they will not feel that they do not belong in the Section until they are older or have more experience in the engineering world. In 1950 approximately 20,000 students were enrolled; this year this figure has dropped about 5,000. He urged the delegates to keep more in touch with the Student Councilors at the colleges in their sections to remedy this decrease in enrollment and to assist the branches in planning more frequent and improved meetings as the student branches are the future life of the Institute.

Past-President Fairman gave a brief statistical report of the opinion polls concerning the unity of the profession. Of the 88 sections contacted, 60 replied; 11½ sections voted for Plan A; none wanted Plan B; 33½ voted for Plan C; 10 for Plan D (the one-half votes were from those who split their votes between Plans A and C, A and D, or C and D); 3 sections wanted none of the plans and 2 sections were unable to come to a decision. Out of 54 subsections polled, 12 answered, 6 being for Plan A and 6 for Plan C. Mr. Fairman asked the delegates to keep the movement alive, as the idea of unity of the profession would take a long time to clarify, especially as the opinions of 14 other engineering societies must be considered. He thanked the section committees who have done excellent work in their replies to this poll; any modifications of the plans or ideas are being considered carefully. He warned that final adoption of a plan was undoubtedly a long way in the future, as it is still in the exploratory stage.

T. G. LeClair (left), AIEE President for 1950–51, presents the Lamme Medal to Donald I. Bohn, chief electrical engineer of the Aluminum Company of America, during ceremonies at the Summer General Meeting held in Toronto. Thomas D. Jolly (third from left), Vice - President and chief engineer, Aluminum Company of America, and A. H. Kehoe, Chairman of the Lamme Medal Committee, spoke at the presentation of the medal

CHANGES IN SECTION TERRITORIES

The next order of business was the changes in status of sections and subsections. The following changes were recommended by vote of the conference and later authorized by the Board of Directors:

The Nashville subsection is now the Nashville Section.

The Sangamon Subsection and Urbana Section have combined under the name of the Central Illinois Section.

The Tri-State Division of the West Virginia Section is now known as the Tri-State Section.

The Western Virginia Section has changed its name to the Virginia Mountain Section.

The Jackson Subsection of New Orleans has been changed to a section to be known as the Mississippi Section.

Mr. J. D. Tebo, chairman of a subcommittee to review section representation at district meetings, reported four possible solutions from his subcommittee and it was recommended that the Section Chairman and one other officer selected by the Section Executive Committee attend the district meetings. This was put in the form of a motion, seconded, and carried.

SECTION AWARDS

Mr. Anzini then introduced President LeClair, who stated that a subcommittee had been working on the matter of recognition of section membership growth and had evolved a formula concerning the attendance at meetings, the membership growth, the size of the section, and other factors, which will be explained in a forthcoming issue of

Ten nations were represented at the AIEE Summer General Meeting. Among them were, left to right: A. Z. Huq, East Pakistan; C. M. Lytle, Kansas City, Mo.; M. Maung, Rangoon, Burma; N. D. Mishra, Lucknow, India; W. R. Way, Montreal, Canada; F. J. Stanger, Melbourne, Australia; Taylor Reed, Reedsville, Pa.; R. H. Hillery, Toronto, Canada; J. E. Boul, Stafford, England

Electrical Engineering. The awards made this year were first and second prizes for those sections with memberships above and below a certain average, the first prizes being rosewood gavels and blocks and the second prizes certificates.

President LeClair announced the following awards:

First prize, larger than average section, to the Connecticut Section, accepted by Professor Turner for the section; second prize in this class to the North Texas Section, accepted by Mr. Rogers.

First prize, smaller than average section, to the Erie Section, accepted by Mr. Lewis for the section; second prize to the North Carolina Section, Mr. Martin accepting the certificate.

COMMITTEE REPORTS

Mr. W. D. Barrett, Chairman of the Finance Committee, talked on the Institute finances, which are now in the black; this has been done by reducing some of the membership services. He urged that the technical activities be allowed to grow, which may mean increased membership dues, as this is the real function of the Institute and so should be encouraged.

Mr. J. C. Woods, Chairman of the Membership Committee, reported that 6,250 applications had been processed in the past year of which 4,168 were from students, only one-third of those graduating. If this ratio is not increased in the next few years, the AIEE membership of younger men will suffer inasmuch as the estimates of electrical engineers graduating up to 1954 is on the decline. An extra effort must be made to induce more students to join the Institute after they graduate. This can be done by the sections' membership committees which can encourage improved programs, and subsection growth and formation to attract and hold new members. Section chairmen should see that their Membership Committee chairmen are appointed promptly and that headquarters is notified as soon as possible.

Because of the absence of C. W. Fick, Chairman of the Transfers Committee, Mr. F. W. Willcutt read Mr. Fick's report. There is to be a tightening up of the transfers of members from one grade to another so that such transfers will have a greater meaning. The grade of Fellow is available from now on only by invitation and a manual explaining this and other changes in membership grades is in preparation and will be sent soon to local Transfers Committees.

President LeClair amplified this report, explaining the newly created grade of Affiliate member, which is a nonvoting membership for those persons who are not necessarily engineers but who are interested in electrical engineering. Mr. Fairman said that the primary purpose of the new grade is to distinguish between the electrical engineer and the man who is just interested and who wishes to be associated with the Institute.

When the meeting was thrown open to discussion, Mr. Anzini stated that subsections are a wonderful incentive to section membership; sections should encourage the establishing of subsections, and after they are formed the sections should assume a parental attitude over them.

Mr. Anzini asked for an indication of the number of sections that were using the progressive election of officers as outlined in the model By-Laws for sections. The delegates indicated that approximately two-thirds of the sections were using the model, the remainder using other methods of elections.

The problems of attendance at section meetings were discussed. Some sections get along without dinner meetings; others find them necessary. The matter of section finances was discussed and how they influenced the type of meetings.

Forum of Technical Committee Chairmen Discusses Publications and Divisional Operation at Meeting

The third Forum of Technical Committee Chairmen to provide an exchange of views under the expanded technical committee structure was held on Wednesday evening, June 27, with K. B. McEachron, Chairman of the Publication Committee, presiding.

President T. G. LeClair, Honorary Chairman, opened the meeting with a brief history of the Institute's expanding activities and the establishing of more technical committees. It is his belief that more meetings of this type are essential to assure the Institute's unity.

Prof. C. H. Willis, Chairman of the Technical Program Committee, brought two questions to the meeting: (1) Should subcommittee chairmen who organize programs for technical sessions be invited to the Forum? (2) Should the Technical Program Committee sponsor a forum meeting in early September?

It was brought out that subcommittee chairmen, especially those dealing with science and electronics, would greatly benefit by attending a forum as they could gain an insight into the functioning of committees and their duties; also many subjects could well be discussed in the forum which would have a bearing on subcommittees' work.

In the discussion following it was stated that although many committees and subcommittees are late in getting started, the new personnel are advised of their appointment and so they could attend a forum held during the Summer General Meeting, at which time they could receive advice, suggestions, and instructions. It was recommended that subcommittee chairmen be invited to the forums in the future and that two such meetings be held.

CONFERENCE AND UNPUBLISHED PAPERS

C. S. Rich, Publication Committee, in a continuation of the discussion at the last forum in New York concerning the growth of the number of conference papers and their publication and the decline of *Transactions* papers, first gave a brief history of the technical conference and district papers, which originated about 20 years ago in the form of round-table forums for informal discussion by groups of specialists and were not intended for publication or to be reported. The increase in conference papers and in the number of published papers in proportion to the growth of membership over a 20-year period was shown: the gross publication cost per member has risen from $7.55 in 1930 to $11.80 in 1950; printing costs have risen more than 50 per cent within the past six years and the cost of paper has increased more than 200 per cent since 1933.

Mr. Rich next presented an estimate of the cost of reproducing the conference papers in the same way the regular papers are done. Taking the number of unpublished papers [that is, conference, district, and Advance-Copies-Only (ACO's)] as 465 up to September 30, 1951, as a basis, their reproduction costs, the cost of a necessarily increased staff, and additional office and storage space amounted to approximately $58,000. Income from sales was estimated at $26,000, giving an annual estimated cost of approximately $32,000 at today's prices.

After analyzing the advantages and disadvantages of conference papers, the speaker considered the matter of raising the standards of *Transactions* papers. During the years 1935 to 1937 an average of approximately

26 per cent of the papers submitted was rejected. So far this year, the Institute has rejected a little more than 11 per cent. The opinion has been expressed that the Institute could not produce more than 300 high-quality papers annually.

Although no quorum was present at a meeting of the Publication Committee held the day previous, Mr. Rich reported that that committee had considered the matter of making conference papers available. Their deliberations were along the following lines:

The practice should not be followed of pushing over papers as conference papers or ACO's—papers which were not acceptable as regular papers or which could not be accommodated within the budget.

An author's manuscript of a conference paper should be reproduced as it is received even though some illustrations might turn out blank. Copy requirements are being studied by a special committee.

The possibilities of finding an outside firm to fill orders and mail the conference papers are being explored.

Unpublished conference papers and ACO's should be listed at the end of the *Transactions* Index.

Advance copies of conference papers should have a standard price which will cover their cost as closely as practicable.

Mr. Rich concluded with the fact that the Institute is publishing more articles and papers annually than any of the founder societies or the Institute of Radio Engineers. The figure of 415 papers and articles he gave does not count digests or abstracts and any paper that is published in both *Electrical Engineering* and the *Transactions* was counted but once.

During the discussion which followed it was brought out that more emphasis should be placed on the quality of conference papers than on their quantity; that one of the founder societies requires that authors supply about 150 to 250 copies of their papers which are placed on sale; that it be left up to the sponsoring committee whether or not certain conference papers be printed; that conference papers do have a place in the Institute's programs and are important.

A motion was put before the Forum that authors be requested to furnish copies of their conference papers and that they be sold at an unspecified price. This motion was seconded and carried.

The question of listing unpublished papers' titles in the *Transactions* Index was put before the Forum. This proposal was not carried.

DIVISIONAL OPERATION

M. D. Hooven, Chairman of the Planning and Co-ordination Committee, introduced the subject of operation of the Institute on a divisional basis. After briefly summarizing the subject and stating that it had many ramifications, he called on some of the members to give their ideas to the Forum so that those present could give the matter thought.

A. E. Knowlton said diversification in the Institute was essential; members who were dissatisfied with the scope of Institute activities had formed other societies; his conclusion was that the different groups should have more autonomy.

M. J. Steinberg posed a series of questions for those present to consider. Should an incoming committee chairman have the choice of his committee members and would this be an improvement? Do we need an improvement in the handling of programs as set up by the various committees? Should committee chairmen have more of a say in the matter of the publication of papers? Should committees have more to say about the establishing of standards? Should a Divisional Adviser be appointed or elected and if elected, by whom? Should a Divisional Adviser be a member of the Board of Directors? Should the powers of the Technical Advisory Committee be broadened? How shall divisions be divided on meeting programs?

These and other questions were presented by Mr. Steinberg who concluded his remarks with the fact that five years' experience has shown that the divisional plan has been most fruitful, but there are many dual functionings calling for change and such changes as are necessary should come from the Forum.

L. F. Hickernell saw no need for any great change unless the Institute intends to change to divisional meetings.

C. H. Willis stated that the so-called Ashville Resolution of 1946 (under which the Institute is operating today with five main technical divisions) does not go far enough; the welfare of the Institute must be the paramount thought. More members should have a voice in committee activities; three divisions instead of five are sufficient; the right of a technical committee to go to the Board of Directors should be kept; and committee chairmen should be elected by technical committee members.

J. L. Callahan stated that our divisional structure is sound; perhaps more divisions will be needed eventually. A pyramid type of streamlined organization is needed with representation to the top; technical activities should be represented on the Board of Directors.

The fact that the *Transactions* are not made attractive enough to the younger members was brought out by W. G. Dow; the main objective was not only the survival but growth of the Institute and one means of obtaining this was to have a representative of each division on the Board of Directors.

President LeClair stated that the divisional organization is informal and that the scopes of the divisions are not in the By-Laws. The Planning and Co-ordination Committee and the technical committees should put their ideas in writing. Mr. Hooven replied that the Planning and Co-ordination Committee had such an aim and that the thoughts expressed in the present Forum are most welcome.

J. R. North, Standards Committee, spoke on the standard balloting procedure when voting on standards in committees. He asked for deliberate action when such a vote is taken in committee so that a proper

Domestic Appliances Conference Held May 15

A technical conference on domestic appliances, sponsored by the Committee on Domestic and Commercial Applications, in co-operation with the Columbus Section, was held at the Battelle Memorial Institute, Columbus, Ohio, on May 15. In the front row, left to right, are W. W. Kuenn, Owens-Corning Fiberglas Company, who spoke on thermal and electric insulations for appliances and related equipment; H. B. Whitaker, Underwriters' Laboratories, who outlined the problems associated with the grounding of appliances; A. J. Nerad, Research Laboratory, General Electric Company, who talked of the significance of research in the consumer goods field; and C. F. Scott, Chairman of the committee. Cochairmen for the meeting were C. R. Reid, Chairman of the Subcommittee on Domestic Appliances, and Roger Merrill, Chairman of the Columbus Section, shown in the back row, left to right. Next to them are W. B. Buchanan, T. H. Cline, R. F. Zimmerman, and J. P. Harris, all members of the committee. H. W. Russell (not shown), assistant director of Battelle Institute, told the meeting of the growth of his Institute's activities, its present facilities (now in substantial part devoted to work for the Armed Services), and the need for further research in the consumer goods field.

consensus may be reached. The Standards Committee needs the proper guidance as they are unable to be familiar with all the standards which they have to consider. Mr. North distributed to the Forum a memorandum prepared by a working group of which he was chairman which set forth proposals for balloting procedures; he requested that opinions be sent in.

R. K. Honaman, Publication Committee, drew attention to the need for ways and means which would permit important papers to be published by the Institute for the benefit of its membership even though they had been previously published in other publications of small circulation with but little overlap of readership with the Institute's publications. Mr. Abraham added that another society had agreed to publish certain papers in its journal even though they had had prior publication.

Mr. Rich expressed the view that inasmuch as the Institute has a definite By-Law which prevents the release of papers for publication in advance of presentation, it was logical that the policies with respect to *Electrical Engineering* should follow suit. Furthermore, as *Electrical Engineering* can only carry about one-third of the material recommended by the technical committees, he did not believe the Institute would be justified in republishing material already available in more complete form in reference libraries. He also pointed out that there never has been any objection to the arrangements for simultaneous publication with other editors and that this has been done frequently on a cordial relation basis. No editor likes to use material previously published as such a policy leads to loss of prestige for the publication.

In the discussion which followed views were expressed that a society should have prior option on material to be published.

Technical Sessions at Summer General Meeting

Range Throughout Five Division Activities

Technical sessions were sponsored throughout the whole range of Institute activities and by each of the five divisions. Sessions sponsored by general committees or subcommittees of general committees dealt with safety, statistical methods, management, and a round-table conference session on temperature correlation in the connection of insulated wires and cables to electric equipment. In another session, the winners of the five District Branch Paper Prizes in the odd-number districts gave their papers.

In the field of communication, sessions were held on wire communications and on a broad-band transcontinental radio relay system.

In the science and electronics division, nine sessions were held dealing with electronic power converters, electronic instruments, making electronic research projects successful, basic instruments, nucleonics, metallic rectifiers, computing devices, and basic sciences.

In the general applications division, two sessions were held which dealt with land transportation. The industry division sponsored seven sessions which dealt with the petroleum industry in Canada, electrostatic processes, industrial power systems, feedback control systems, mining and metal industry, and industrial control problems.

The power division sponsored 16 technical sessions which dealt with generation, transmission, distribution, system engineering, telemetering, carrier current, and associated apparatus such as protective devices, switchgear, transformers, relays, and insulated conductors. Many of the papers in each of the several divisions dealt with the latest Canadian practices and these were appropriate by virtue of location of the meeting. Some of the many sessions are reported in more detail in the following paragraphs.

PHILOSOPHY BEHIND RESEARCH

Although the title of the session presided over by W. C. White of the General Electric Company was "Making An Electronics Research Project Successful," the Chairman announced that the sponsoring committee asked the four speakers to bring out the philosophy behind the research projects "instead of just describing the steps followed toward the final outcome of their projects."

The session was opened by J. W. Coltman, Westinghouse Electric Corporation, who presented "Teamwork in Research Produces the Fluoricon." Defining successful research as one which provides a monetary return, the author differentiated between fundamental and developmental research; the former is that form of research which gives a wider scientific knowledge and the latter is a search for better tools—the subject matter is paramount. The Fluoricon resulted from teamwork.

The first phase of the project was study—a review of the work already accomplished along the lines of the amount of X-ray dosage and the resulting picture brightness. Then a resolution of the problem to be solved and the steps thought to be necessary for its solution were set up. The X-ray image is the result of quanta and they depend on the thickness of that part of the patient which is being observed. The first question: can images be amplified which are composed of a series of flashes? It was established that the limit of amplification was 1,000 times and at this time the conversion of X rays into light rays was under consideration. It was while studying this phase that a by-product was born—the scintillation counter. This brings out the fact that the aims of any research project should not be restricted—apparently a side line nearly always appears.

After describing the Fluoricon, its optical system, and the many mechanical difficulties encountered, Mr. Coltman told how different groups solved the various problems, in which teamwork was the usual thing. He stated that rarely can the right man for the right job be found. Experts are developed as work progresses; the main factor is close co-operation between the technicians and the scientists. A team is essential for successful research.

Doctor White, Chairman of the session, started the discussion by speaking about the importance of the research by-products mentioned. In his company the word for this is "serendipity" and he told about its derivation.

"Some Case Histories of Electronic Research" was the title of the next paper by R. M. Bowie, Sylvania Electric Products, Inc., instead of the paper which was to have been presented by E. H. Schulz of Armour Research Foundation, who was ill.

Mr. Bowie defined research as the attempt to see if anything interesting can be found in anything fundamental. In describing the development of the Panelite, he told about decentralization of authority—how one man is responsible in each division of the organization. The ioinzation gauge was an outcropping of oil distillation—a side line. It was given to various research departments, then to the manufacturing department, and finally to a pilot plant. He warned that development should be as quick as possible to reduce cost.

In telling about the magnetron and the klystron, it was found that model-shop samples were satisfactory after testing by the research department where the specifications were made, and not in the pilot

Ridgway Subsection Dinner Meeting Held

C. G. Veinott, AIEE Vice-President of District 2, was the guest speaker at the annual dinner meeting of the Ridgway (Pa.) Subsection, held May 9. Shown here are officers and committee members of the subsection: front row, left to right: R. F. Edwards, Chairman, Ridgway Subsection; A. A. Jedrziewski, Executive Committee Member; Mr. Veinott; and W. H. Austry, Program Committee Member. In the rear row, left to right, are: E. I. Pollard, Chairman, Awards Committee; C. F. McGinnis, Vice-Chairman, Ridgway Subsection; S. N. Blaskett, Chairman, Historical Committee; J. W. Weaver, Chairman, Transfers Committee; and W. P. Van Vranken, Chairman, Publicity Committee

Board of Managers of Lehigh Valley Section Holds First Meeting

AIEE Lehigh Valley (Pa.) Section of District 2 recently held a reorganization meeting in Hazleton, Pa., when incoming Chairman John O. Leslie met with the new members of the Board of Managers to discuss plans for the 1951–52 season. Seated (left to right), W. C. Seymour; J. H. Black; G. M. Keenan, Retiring Chairman; J. O. Leslie, Chairman; A. B. Snavely; D. A. Campbell; F. W. Smith. Second Row—W. F. Mackenzie; A. L. Price; H. R. Wilbur; D. L. Greene; W. B. Morton; A. W. Plonsky; E. F. Weaver; H. E. Pearson; F. T. Ritter. Third Row—B. B. Kern; L. L. Nonemaker; L. Z. Ludorf; D. O. Eschbach; J. E. Treweek; E. W. Taylor; and G. E. May

plant. Research men should test their own products. The setting of boundaries between two operating departments should be such that there is free communication; tools as well as information should be commonly shared. The direction of research is becoming a profession.

The final speaker of the session was J. B. Fisk, Bell Telephone Laboratories, Inc., whose subject was "The Transistor—A Case History of Research and Development." After describing the transistor and the new junction transistor, Mr. Fisk told how for 20 years a group of theoretical and experimental physicists and chemists had given their attention to semiconductors in the communications field. They worked on fundamental questions, such as: How are atoms arranged? How did they come about? The answers they found were the result of a continual exchange between the theoretical and experimental groups. The developmental group studies all phases of the question—making devices, using the product, studying it, and finding its role.

ELECTROSTATIC PROCESSES

The session on electrostatic processes was held Wednesday under the chairmanship of G. W. Hewitt, Westinghouse Electric Corporation, and was sponsored by the Subcommittee on Electrostatic Processes. The opening paper, "Electrostatic Sources of Ionizing Energy," was presented by J. G. Trump, Massachusetts Institute of Technology (MIT). The growing need in scientific circles for intense sources of high-energy particles and other forms of ionizing energy is being met with devices which depend on electrostatic forces and principles. The Van de Graff electrostatic accelerator has emerged within the last ten years as the instrument for precision nuclear research in the binding-energy range. So far the electrostatic generators in use throughout the world have energies below 4,000,000 volts. Today two Van de Graff electrostatic accelerators in this country are nearing completion, which will have 12,000,000 volts output.

The speaker outlined the uses to which Van de Graff generators in the past have been put: X-ray therapy, industrial radiography, and electron sterilization among others. After describing the one in the course of construction at MIT and the principles on which it will operate, he told what could be expected in the future by using its supervoltage output.

H. J. White, Research Corporation, read his paper, "Particle Charging in Electrostatic Precipitation." Electric charging of aerosols is basic to electrostatic precipitation and related process and it also has inherent scientific interest. Experience has indicated that the unipolar corona discharge provides the best practical means of highly charging suspended particles in gases, which early workers in the field did not investigate; rather they regarded it as an integral part of the over-all precipitation process. During the past 25 years, studies have provided a satisfactory foundation for the particle-charging process and the author presented a a résumé of these studies.

Two particle-charging mechanisms are present in the unipolar corona discharge: bombardment of the particles by ions moving in the d-c field and attachment of ions to the particles by ion diffusion. The first process leads to a particle charge which is proportional to the d-c field strengths and to the surface area of the particle and this is the process of importance in electrostatic precipitation. The second process does not depend on an external field and is important only for particles smaller than approximately 0.2-micron diameter. It has been found in the field that there is a general agreement between the results of studies there and theory.

"Electrostatic Precipitation of High-Resistivity Dust" was given by G. W. Penney, Carnegie Institute of Technology. High-resistivity dusts may result in excessive gradients across the layer of collected dust in the large electrodes of the ionizer, which results in electrical breakdown through this layer and a negative corona at the surface of the large electrode. This supplies negative ions to neutralize partially the normal positive charge given to the dust particles. The efficiency of precipitation is reduced by reverse ionization and causes excessive ozone generation and wire vibration. Reverse ionization is probable if the resistivity of the dust is more than 10^{11} ohm-centimeters and is improbable below 5×10^{9} ohm-centimeters. Control of humidity can keep the resistivity of the collected dust below objectionable limits and is usually an effective means of eliminating reverse ionization. Another means of eliminating trouble is by the use of adhesives.

The final paper of the session, "Distribution of Charge in Electrostatic Separation," was given by Foster Fraas and O. C. Ralston, both of the Bureau of Mines. The simplest and commonest type of electrostatic separator is one with a pure electrostatic separator with negligible leakage between the electrodes, which are a pair of horizontal cylinders several inches apart with one of them rotating so that granular material fed into its top section will be carried between it and the other cylinder thus passing through an electrostatic field. The potential commonly used is seldom more than one-half the spark-over voltage and the electrode carrying the solid particles may be at ground potential. The other electrode may be charged either positively or negatively with respect to ground. Often 5,000 to 20,000 volts per inch of gap are employed according to the size of the gap. When the particles are carried into the electric field, they acquire charges by induction and interfacial conduction, hence their deflection distance depends on the amount of charge.

TRANSFORMERS

Among the several sessions in the power division, great interest was shown in the session on transformers which dealt largely with the use of inhibited oils. Well-known authors with operating companies and prominent designers took part in the presentations and discussions with J. R. Meador presiding. The subject becomes more important as system loadings increase and when it is considered that on the average 6/10 gallon of oil is used in oil-filled transformers and associated regulators and circuit breakers for each kilovolt-ampere of transformer capacity, as pointed out by Herman Halperin. Also a wide diversity of opinion among operating engineers exists as to what constitutes the life of oil, as pointed out in the paper by E. D. Treanor and E. L. Raab.

The first paper, which was presented by A. L. Hough of The Shawinigan Water and Power Company, dealt with winter and summer tests on 50,000-kva and 20,000-

kva power transformers of the forced-oil forced-air cooled type with the view toward determining the length of time such transformers may remain in service on the system after the partial or complete loss of the auxiliary cooling equipment.

The second paper, "Inhibited Oils for Transformers," by Herman Halperin and H. A. Adler, was presented by the former author. Three series of transformer tests were conducted under accelerated aging conditions closely simulating service operation on old and new types of 10-kva and 15-kva transformers with the view toward determining the value of conventional oil and inhibited oils. Among the several conclusions in the paper, one indicates that the service life of an inhibited oil in unprotected transformers has been indicated to be twice the life of conventional oil when used as replacement in old transformers. This ratio becomes 3-to-1 for new transformers of the unprotected type.

The third paper, "Relative Performance of Normal Oils with and without DBPC (ditertiary butyl para cresol) Inhibitor in Semisealed Transformers," written by E. D. Treanor and E. L. Raab of the General Electric Company, presented valuable basic data on the characteristics of the oils. Accelerated runs are being made on small transformers with 10-C oil, 10-C +0.3 per cent DBPC, and 10-C +0.4 per cent DBPC. The data obtained indicated that the DBPC inhibitor is an effective oxidation inhibitor as shown by the general improvement observed for the majority of the oil characteristics. The authors intend to continue the study until the inhibitor has been exhausted.

The last paper, by R. G. Call and W. L. Webb of the American Gas and Electric Service Corporation, presented valuable information on a field-screening test for judging the condition of insulating oils in service. Mr. Call, who presented the paper, pointed out that the field screening saves a great deal of laboratory work and expense and it permits more prompt attention to be given to the batches of oil needing attention most urgently.

In the discussion which followed in regard to the first paper, Mr. Ingram of The Shawinigan Water and Power Company explained the difficulty encountered in testing which necessitated taking readings in the field in 21 seconds. S. N. Lawrence of the Canadian General Electric Company, W. G. James of the Westinghouse Electric Corporation, and M. B. Mallett of the English Electric Company of Canada, Ltd., all congratulated the authors of the first paper on the tests which had been made. Mr. Mallett explained that the hot spot indicator has a definite place but due to the presence of thermal gradients in the oil the hot spot temperature indicator does not always indicate true values.

With respect to the papers on inhibited oils, the first discussion was given by Mr. H. A. Cornelius of the Public Service Company of Northern Illinois which has been maintaining approximately 2,500,000 gallons of oil in distribution transformers. One view expressed was that the oxidation problem in insulating oils has been somewhat overexaggerated. In respect to the paper given by Treanor and Raab, attention was drawn to the fact that the paper applied only to the use of inhibited oils in distribution transformers and that some operators undoubtedly would attempt to apply the results to power transformers.

Of the 53 Fellows forming the Royal W. Sorensen Fellows, 32 were present at the Annual Meeting held June 5

SYSTEM ENGINEERING

In a session on the last day which was well attended, six informal papers which dealt mainly with stability and voltage control on different systems were presented in the system engineering session with C. B. Kelley presiding.

The Colfax stability tests were explained by A. P. Hayward of the Duquesne Light Company. After a serious outage of approximately 1 hour due to an operating error, one machine pulled out of step and in attempting to resynchronize oscillations were encountered in the governors on other turbine generators. Operators glancing across the boards saw in instruments readings which did not exist due to a stroboscopic effect. Sixteen-millimeter motion pictures of this effect would be made available on a loan basis for interested companies.

The second paper which was presented dealt with the problem of voltage control on an a-c power system and was given by H. B. Smith of the Niagara Mohawk Power Corporation. The author explained how the necessary tools were obtained to carry out such an operation by proper instruction of operating personnel, citing five fundamental principles of operation, the theory of and technique for obtaining equal voltage boosts, and then demonstrating the five principles by the a-c board tests. In the latter part of the paper, he explained how the tools were used to effect system voltage control to effect the voltage boost on the Niagara Mohawk 66-kv 25-cycle system as well as on the 115-kv 60-cycle system.

The third paper which was presented dealt with the operations of large a-c metropolitan networks of the Kansas City Power and Light Company and the authors were D. H. Cameron and H. W. Phillips.

The fourth paper dealt with the control of voltage on a hydroelectric power system, and it was presented by J. M. Crawford of The Shawinigan Water and Power Company. Practices which are effected on this company's system with regard to voltage control from both planning and operating points of view were presented as well as voltage control problems which arose as the system developed and stronger interconnections were made with adjoining power systems.

The last paper in the session dealt with control of voltage levels and megavar flow on 230- and 115-kv systems of the Hydro-Electric Power Commission of Ontario and it was presented by P. L. Dandeno. The latter part of the paper dealt with the problem of communications and its importance during system faults, and was presented by Mr. Nablo of the Hydro-Electric Power Commission of Ontario.

Annual Meeting of Sorensen Fellows Held in Pasadena

The Royal W. Sorensen Fellows Annual Meeting was held Tuesday, June 5, in the Atheneum at the California Institute of Technology, Pasadena, Calif. Dr. Frederick G. Lindvall, President of the Royal W. Sorensen Fellows, presided. Doctor Sorensen, Past President of the Institute, was the honored guest. Prof. Robert Gray, of the California Institute of Technology, gave a very interesting outline and description of the Institute's new Department of Public Relations.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Note. Because of the changeover in committee personnel, no items on committee activities are included in this issue.

AIEE PERSONALITIES . . . . .

J. F. Fairman (A '20, F '35), Vice-President, Consolidated Edison Company of New York, Inc., New York, N. Y., and past President of the AIEE (1949–50), has been appointed administrator of the Defense Electric Power Administration, Department of the Interior. Mr. Fairman received his bachelor of science degree in electrical engineering in 1918, and his master of science degree in 1921, both from the

University of Michigan, Ann Arbor, Mich. He remained there from 1922 to 1925 as assistant professor of electrical engineering. In 1925 he joined the Brooklyn (N. Y.) Edison Company as an assistant outside plant engineer. He was appointed electrical engineer of the company in 1932, and following the merger of the various predecessor companies into Consolidated Edison Company of New York, Inc., in 1936, he became electrical engineer for the system. In 1941, Mr. Fairman was appointed assistant Vice-President and four years later he was elected Vice-President of the company and is in charge of electric and gas production and operation. He has served the AIEE as Vice-President representing District 3 (1944–46), as Director (1946–49), and as President (1949–50). He has actively served on many Institute committees and is currently serving on the following: Executive; Board of Directors; AIEE Representative on the Engineers Joint Council; General Electric Educational Fund; and the John Fritz Medal Board of Award. Mr. Fairman has served as President of the New York State Society of Professional Engineers, and as Director and Vice-President for the northeastern area (1946–47) of the National Society of Professional Engineers. He is also a member of Tau Beta Pi and Sigma Xi.

S. G. Hibben (A '34, M '45), Director, applied lighting, Lamp Division, Westinghouse Electric Corporation, Bloomfield, N. J., has been elected President of the Illuminating Engineering Society. Mr. Hibben received his technical education at the Case Institute of Technology where he was graduated with a bachelor of science degree in 1910, and an electrical engineering degree in 1914. After graduation in 1910, Mr. Hibben joined the MacBeth-Evans Glass Company, Pittsburgh, Pa., as an illuminating engineer. From 1914 to 1915 he was an illumination consulting engineer in Pittsburgh, and in 1915 he became associated with the Westinghouse Electric Corporation, Bloomfield, N. J., as an illuminating engineer. He became Director of applied lighting in 1933. A Fellow of the Illuminating Engineering Society, Mr. Hibben is a past Director of the society and has just completed a 2-year term as Vice-President. He was a United States delegate to the meeting of the International Commission on Illumination held in Stockholm, Sweden, this summer. He is also a member of the Illuminating Society of London, England, the Electrical and Gas Association of New York, and the Engineers' Club of New York. He has actively served the AIEE on the following committees: Production and Application of Light; Standards; Technical Program; Planning and Co-ordination; Award of Institute Prizes; and General Applications Co-ordination.

T. G. LeClair (A '24, F '40), chief electrical engineer, Commonwealth Edison Company, Chicago, Ill., and past President of AIEE (1950–51), has been awarded the honorary degree of doctor of science from the University of Idaho. Doctor LeClair served as Vice-President representing District 5 (1946–48) and has been a Director of the Institute (1941–45, 1946–48). He has served actively on many of the AIEE committees and was Chairman of the Professional Group Co-ordinating Committee (1947–50) and of the Protective Devices Committee (1942–43). He was Chairman of the Chicago Section of the AIEE from 1929 to 1930, and represented the Institute on the Advisory Board of the National Bureau of Engineering Registration (1946–47). He is a past-President of the Illinois Engineering Council, a past-President of the Western Society of Engineers, and a member of the National Society of Professional Engineers.

C. G. Veinott (A '28, M '34, F '48), manager, induction motor section, Industrial Engineering Department, Westinghouse Electric Corporation, Lima, Ohio, has been awarded the honorary degree of doctor of engineering by the University of Vermont for his work in the small motor field, his work in Eta Kappa Nu, and his work in the AIEE. Doctor Veinott served the Institute as Vice-President of the Middle Eastern District from 1949–51 and was a member of the Rotating Machinery Committee (1934–38, 1942–51). He was Chairman of the Special Committee for the Study of Recognition of Section Growth (1950–51).

M. M. Brandon (A '28, F '44), Vice-President and electrical engineer, Underwriters' Laboratories, Inc., New York, N. Y., has been appointed Chairman of the Electrical Correlating Committee and of the Electrical Section of the National Fire Protection Association. He succeeds Mr. **Alvah Small** (M '37, F '43), Vice-Chairman, Underwriters' Laboratories, Inc., Chicago, Ill., who has retired. Mr. Brandon was graduated from Mississippi State College in 1919 with a bachelor of science degree in electrical engineering. He joined the Underwriters' Laboratories as an assistant engineer in 1921; in 1924 he became service engineer; and in 1927 he was appointed chief inspector. From 1928 until 1944 Mr. Brandon was associate engineer, when he was appointed Vice-President. He has actively served the AIEE on the following committees: Domestic and Commercial Applications (1943–51, Chairman 1947–49); Safety (1944–51); Standards (1944–51); Technical Program (1947–50); Insulated Conductors (1947–48); and General Applications Co-ordinating (1947–49). Mr. Brandon is also a member of Tau Beta Pi.

H. I. Romnes (A '41, M '47), general manager, Long Lines Department, American Telephone and Telegraph Company, New York, N. Y., has been promoted to director of operations. Mr. Romnes was graduated from the University of Wisconsin in 1928 with a bachelor of science degree in electrical engineering, and became associated that same year with the Bell Telephone Laboratories. In 1935 he was transferred to the Operation and Engineering Department. As a member of the toll transmission group, he worked on the engineering of many of the long-distance facilities of the country. In 1946 Mr. Romnes was placed in charge of this group. He also served as a radio engineer in charge of the radio section of the company. Mr. Romnes has actively served the Institute on the following committees: Communications (1945–49); Communications Co-ordinating (1949–50, Chairman 1949–51); Technical Program (1949–50); Award of Institute Prizes (1949–50); Planning and Co-ordination (1949–50); Technical Advisory (1950–51). He is also a senior member of the Institute of Radio Engineers.

R. W. Atkinson (A '09, F '28, Member for Life), chief research engineer, General Cable Corporation, Bayonne, N. J., has been named the 13th winner of the Marston Medal for achievement in engineering given by Iowa State College. Mr. Atkinson was graduated from Iowa State College with a bachelor of science degree in electrical engineering in 1906 and in 1911 he received the electrical engineering degree. In 1908 he became associated with the Standard Underground Cable Company, Pittsburgh, Pa., and remained with the company after

J. F. Fairman

S. G. Hibben

T. G. LeClair

C. G. Veinott

it became the General Cable Corporation. He has held the positions of chief electrical engineer, director of high-voltage research, and is now chief research engineer. He has actively served the AIEE on the following committees: Power Transmission and Distribution (1929–30); Research (1933–41); Standards (1934–51); and Board of Examiners (1945–51).

The following were among the number representing the United States at the meeting of the International Electrotechnical Commission in Estoril, Portugal, from July 4–12, 1951: **H. S. Osborne** (A '10, F '21, Member for Life), chief engineer, American Telephone and Telegraph Company, New York, N. Y.; **R. C. Sogge** (M '35), manager, standards division, Executive Department, General Electric Company, Schenectady, N. Y.; **H. R. Arnold** (A '31), supervising engineer, transformer division, Westinghouse Electric Corporation, Sharon, Pa.; **V. L. Cox** (A '28, F '50), manager of engineering, switchgear division, General Electric Company, Philadelphia, Pa.; **C. L. Dawes** (A '12, F '35, Member for Life), Professor, Department of Electrical Engineering, Harvard University, Cambridge, Mass.; **C. W. Falls** (A '21, M '45), manager, small and medium motors division, General Electric Company, Schenectady, N. Y.; **C. M. Laffoon** (A '24, F '45), manager, A-C Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pa.; **E. F. Seaman** (M '43), head engineer, standardization planning branch, Bureau of Ships, Department of the Navy, Washington, D. C.; **C. F. Wagner** (A '20, F '40), consulting engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa.; **W. C. Wagner** (A '06, F '41, Member for Life), staff engineer, Executive Department, Philadelphia Electric Company, Philadelphia, Pa.; and **J. W. McNair** (A '25), electrical engineer, American Standards Association, New York, N. Y. Doctor Osborne, past President of the AIEE (1942–43), headed the delegation.

A. B. Clark (M '19, F '30), Vice-President, Bell Telephone Laboratories, Inc., New York, N. Y., has been given the responsibility of co-ordinating all Bell System programs at the Laboratories. Mr. Clark joined the American Telephone and Telegraph Company (AT&T) after his graduation from the University of Michigan in 1911. From 1911 to 1934 he was a member of the Development and Research Department of AT&T and joined the Bell Laboratories when that department was consolidated with the Laboratories. He was named director of transmission development in 1935 and in 1940 he became director of systems development. In 1944 Mr. Clark was made a Vice-President of the company. He served on the AIEE Communications Committee (1937–38). He is also a member of Tau Beta Pi; Sigma Xi; a fellow of the Acoustical Society of America; and a member of the Institute of Radio Engineers and the American Association for the Advancement of Science.

J. W. McRae (A '37, M '50), director, transmission development, Bell Telephone Laboratories, Inc., Murray Hill, N. J., has been appointed Vice-President in charge of systems development. Doctor McRae has been associated with the Laboratories since 1937. From 1942–45 he served in the Signal Corps of the United States Army and attained the rank of lieutenant colonel before returning to civilian life. In 1946 he was appointed director of radio projects and television research at the Laboratories and after successive promotions he was made director of transmission development in 1949. Doctor McRae is also a fellow of the Institute of Radio Engineers, and is a member of Sigma Xi.

S. W. Herwald (A '46, M '49), manager, development section, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed engineering manager of the special products development division. He was graduated from the Case Institute of Technology in 1938, with a bachelor of science degree in mechanical engineering. He received his master's degree in 1940 and doctor of philosophy degree in 1944 from the University of Pittsburgh (Pa.). Doctor Herwald joined the Westinghouse Electric Corporation in 1939 and was assigned to central engineering. In 1946 he became section manager in special products engineering, and in 1951 was made development engineering manager of the same department. He is a member of the American Society of Mechanical Engineers and Sigma Xi. He is currently serving the Institute as Chairman of the Feedback Control Systems Committee and on the Industry Division Committee.

W. P. Dobson (A '13, F '43, Member for Life), Director of Research, Research and Testing Department, Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada, has been awarded the honorary degree of doctor of science by Queen's University. Doctor Dobson is a past Vice-President (1925–27) of the AIEE and has served actively on many committees. He is currently serving on the Safety and Standards Committees.

K. S. Geiges (A '31, M '41), service engineer, Label Service Department, Underwriters' Laboratories, Inc., New York, N. Y., has been appointed chief electrical engineer of the company. Mr. Geiges graduated from Newark (N. J.) College with a bachelor of science degree in electrical engineering in 1928 and joined the staff of Underwriters' Laboratories the same year as assistant electrical engineer. Later he was appointed associate electrical engineer and then service engineer. After serving in the United States Navy during World War II he was placed in charge of the Electrical Department. Mr. Geiges has served the Institute on the Electronics Committee (1947–49), and on the Metallic Rectifiers Committee (1949–51).

F. E. Brooks (A '38, F '48), chief engineer, New York Telephone Company, New York, N. Y., has been elected a Vice-President of the company. He entered the company as an engineering assistant after graduating from Case Institute of Technology in 1912. In 1939 he became chief engineer in the Bronx-Westchester area of the company and subsequently served in the same post in Long Island and the combined Manhattan-Bronx-Westchester area. During World War II he was an assistant Vice-President in charge of placing company personnel in communication assignments in the Armed Forces. For the past year he has served as staff assistant Vice-President in charge of plant engineering. Mr. Brooks is also a member of Eta Kappa Nu.

A. V. Hughes (A '48), research engineer, electrical engineering division, Battelle Memorial Institute, Columbus, Ohio, has been appointed Director of Engineering and Research, Kuhlman Electric Company, Bay City, Mich. Mr. Hughes received his bachelor of science degree in electrical engineering in 1937, and his master of science degree in 1938, both from the Massachusetts Institute of Technology. From 1940 to 1950 Mr. Hughes was associated with the Westinghouse Electric Corporation. His experience also includes association with the Delco Products Division of the General Motors Company, and with the General Electric Company. He currently is serving the AIEE on the Transformers Committee.

G. E. Rolston (A '30), Vice-President and Director of Sales, Rome Cable Corporation, Rome, N. Y., has been appointed chief of the wire and cable branch in the Metal and Minerals Bureau of the National Production Authority's copper division, Washington, D. C. Following engineering and sales positions with the United Gas Improvement Company and the General Cable Corporation, he joined the Rome Cable Corporation in 1936 and was elected Vice-President and Director of the company in 1945. Mr. Rolston is also a member of the American Society for Testing Materials, National Electrical Manufacturers Association, American Standards Association, and the Technical Advisory Committee of the War Production Board.

C. M. Slack (M '43), technical director, Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been awarded the honorary degree of doctor of science by Marietta College. Doctor Slack was graduated from the University of Georgia in 1922 with a bachelor of science degree. In 1923 he obtained a master's degree and three years later his doctor of philosophy degree, both from Columbia University. In 1927 he became associated with the Westinghouse Electric Corporation. Doctor Slack served the Institute on the Therapeutics Committee from 1947–50.

W. J. Ellenberger (A '31, M '38), facilities planning engineer, National Bureau of Standards, Washington, D. C., has been recalled to military service with the Office of the Assistant Chief of Staff, United States Army, and assigned to the Research and Development Division. Lieutenant Colonel Ellenberger has been associated with the

National Bureau of Standards since 1946. His AIEE activities include membership on the Industrial Power Systems Committee and he has been elected secretary-treasurer of the Washington Section for the year 1951–52.

G. P. Daiger (A '31, M '41), chief engineer, Engineering Department, The Hoover Company, North Canton, Ohio, has been made executive assistant in the company's administrative offices with duties relating to production. Doctor Daiger, who received his doctorate degree from Johns Hopkins University in 1932, joined The Hoover Company the same year to take charge of the company's acoustical laboratory. He was placed in charge of the electrical laboratory in 1934 and in 1939 was promoted to staff engineer. In 1940 he was appointed Director of Laboratories and co-ordinated the company's research activities and experimental testing. From 1944 until his current promotion he was successively executive, then chief engineer in charge of all the company's technical activities.

Alan Howard (A '28, M '35), division engineer, gas turbine engineering division, General Electric Company, Schenectady, N. Y., has been appointed operation manager for the gas turbine division. Mr. Howard became associated with General Electric in 1927 and from 1930 to 1936 he was in charge of the company's advanced engineering training program. He was transferred to the turbine-generator division and in 1947 he was appointed section engineer of the present gas turbine engineering division. In 1948 he was appointed division engineer of the gas turbine division, a position he will retain with his new appointment. Mr. Howard served the Institute on the Education Committee from 1934 to 1936.

L. J. Linde (A '39, M '45), consulting engineer, **H. P. Pinkham** (M '46), assistant engineer-in-charge, Boston Works, **G. W. O'Keefe** (M '46), sales engineer, **A. E. Kilgour** (A '39, M '47), application engineer, and **C. D. Ainsworth** (M '46), engineer-in-charge, Engineering Department, Allis-Chalmers Manufacturing Company, Boston, Mass., have been appointed respectively to the following positions: assistant general manager and chief engineer; assistant chief engineer; manager of sales; assistant manager of sales; and standards engineer.

I. S. Coggeshall (M '37, F '48), general traffic manager, International Communications Department, Western Union Telegraph Company, New York, N. Y., has been awarded the honorary degree of doctor of engineering by the Worcester (Mass.) Polytechnic Institute. Doctor Coggeshall is currently serving the AIEE as Chairman of the Telegraph Systems Committee and as a member of the Communications Co-ordinating Division Committee.

L. F. Giegel (A '48), electrical engineer, Reliance Electric and Engineering Company, Cleveland, Ohio, has been appointed branch manager of the Gary, Ind., sales office of the company. He joined the company in 1947 following graduation from the Illinois Institute of Technology, with a bachelor of science degree in electrical engineering, and since has been attached to the company's Applied Engineering Department.

M. I. Alimansky (A '45, M '50), assistant manager of manufacturing, General Electric Company, Pittsfield, Mass., has been appointed assistant manager of engineering for the transformer and allied products divisions. In 1929 Mr. Alimansky joined the company's capacitor engineering division and became manager of that section in 1942. He was named engineer-in-charge of the capacitor divisions in 1943 and remained in that position until 1950, when he was appointed assistant to the manager of engineering.

J. W. Dawson (M '35), supervisor, electronic miniaturization, Stanford Research Institute, Stanford, Calif., has been appointed chief engineer for the electronics division, Sylvania Electric Products, Inc. From 1926 to 1937 he was associated with the Westinghouse Electric Corporation; from 1937 to 1949 he was with the Raytheon Manufacturing Company. Mr. Dawson is a member of Tau Beta Pi, Eta Kappa Nu, and the Institute of Radio Engineers. He served the AIEE on the Electric Welding Committee (1936–46).

L. B. Gezon (A '46), sales engineer, Central Station Department, General Electric Company, New York, N. Y., and **O. A. Huntsman** (A '46), utility supervisor, municipal and transportation section, General Electric Company, Philadelphia, Pa., have been appointed sales manager and assistant sales manager respectively of the metal-clad and switchboard section of the General Electric Company's switchgear divisions at Philadelphia.

E. B. Steinberg (A '42, M '48), advanced research laboratory, Remington Rand, Inc., South Norwalk, Conn., has joined the Reflectone Corporation, Stamford, Conn., as engineer-in-charge of the science division. Mr. Steinberg is the author of many technical articles and is the holder of several patents in the electronic field.

W. L. Winter (A '21, M '43), application engineer, Westinghouse Electric Corporation, San Francisco, Calif., has been promoted to the position of assistant to the manager, Central Station Department, Pacific Coast District. Mr. Winter has been with the company since 1916. He served the Institute on the Electric Machinery Committee (1937–38).

H. W. Giesecke (A '35, M '42), new products division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been named assistant to the general manager of the Bendix Radio Division, Bendix Aviation Corporation, Baltimore, Md. His experience includes association with the Bell Telephone Laboratories, Inc., New York, N. Y.

H. J. Finison (A '43, M '47), assistant chairman, Electrical Engineering Research Department, Armour Research Foundation, Chicago, Ill., has been promoted to Chairman of the Electrical Engineering Department. Mr. Finison was an application engineer for the General Electric Company from 1944 to 1949. From 1940 to 1944 he was an electrical engineer for the Air Materiel Command.

N. E. Funk (A '07, F '34, Member for Life), consulting engineer, Philadelphia, Pa., was elected honorary member of The Engineers' Club of Philadelphia at the Mid-Century Meeting on January 16, 1951. Mr. Funk is a past President of the AIEE (1943–44) and is very active in Institute affairs.

John Romano (A '42), assistant sales manager, Delta-Star Electric Company, Chicago, Ill., has been appointed general sales manager. Mr. Romano has been with the company since 1927. He was employed first in the Engineering Department and then progressed through sales engineering and was appointed assistant sales manager in 1945.

H. L. Durgin (M '40), Vice-President, Central Vermont Public Service Corporation, Rutland, Vt., has been elected a member of the Board of Directors. Mr. Durgin has been an employee of the company since its organization in 1929. He served as electrical engineer from 1929 to 1934, as chief engineer from 1934 to 1943, and as Vice-President and chief engineer from 1943 until 1950.

L. H. Matthes (A '31), assistant manager of sales, large motor and generator divisions, General Electric Company, Schenectady, N. Y., has been promoted to the position of manager of sales. Mr. Matthes has been with the company since 1921.

David DeWitt (A '39), research director, and **Devereaux Martin** (M '43), chief engineer, Radio Receptor Company, Inc., Brooklyn, N. Y., have been promoted to the positions of Vice-President in charge of research and assistant to the President respectively.

C. F. Herbold (A '33, M '41), manager, Industrial Relations Department, Westinghouse Electric Corporation, Lima, Ohio, has been appointed superintendent of quality control for the small motor division. Mr. Herbold has been with the company for 20 years.

B. E. McArthur (A '45), Engineering Department, Aluminum Company of America, Cleveland, Ohio, has been appointed chief engineer for the Magnethermic Corporation, Youngstown, Ohio.

G. E. Walter (A '44), specialty transformer and ballast engineering division, General Electric Company, Fort Wayne, Ind., has been appointed assistant division engineer. Mr. Walter joined General Electric in 1941.

W. H. Radford (A '33, M '48), associate professor of electrical communications,

Massachusetts Institute of Technology, Cambridge, Mass., has been promoted to the rank of full professor.

T. L. Rama Char (A '50), lecturer, Indian Institute of Science, Bangalore, Mysore, India, has been elected honorary secretary of the Bangalore Section of the Royal Institute of Chemistry. He also has been appointed regional editor for India of the Journal of the Electrochemical Society.

J. M. Clema (A '32, M '49), sales and application engineer, Kirkhof Electric Company, Grand Rapids, Mich., has accepted the position of manager of the Nebraska Association of Rural Public Power District and Membership Associations, Inc., Lincoln, Nebr.

D. E. Alexander (A '49), assistant chief engineer, Victor Insulators, Inc., Victor, N. Y., has been appointed chief engineer of the company.

OBITUARY

Dugald Caleb Jackson (A '87, M '90, F '12, Honorary Member '44, Member for Life), retired, Cambridge, Mass., died on July 1, 1951. He was born on February 13, 1865, in Kennett Square, Pa., and received the degree of civil engineer from Pennsylvania State College in 1885. He spent the next two years in graduate study in electrical engineering at Cornell University. His early engineering experience was gained as Vice-President and engineer (1887–89) for the Western Engineering Company, Lincoln, Nebr. He was assistant chief engineer with the Sprague Electric Railway and Motor Company, New York, N. Y. (1889–91), and later was chief engineer for the central district of the Edison General Electric Company. In 1891 he helped form a consulting engineering firm and also became professor of electrical engineering at the University of Wisconsin, Madison, Wis., which position he retained until 1907 when he was appointed professor and Head of the Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. He retained this position until 1935, when he retired as Professor Emeritus. The consulting engineering firm of Jackson and Moreland, organized in 1919, specialized in the fields of electric power production and distribution of railway electrification; Doctor Jackson continued as senior partner until 1930. A past President of the AIEE (1910–11), Doctor Jackson was an active member of the Institute. He served as chairman and member of many committees and was Vice-President (1897–99). He was the recipient of the Edison Medal in 1938 and the Lamme Medal of the Society for the Promotion of Engineering Education in 1931. He was awarded the honorary degree of doctor of science by Columbia University and the honorary degree of doctor of engineering by Northwestern University. He was the author of several books on electrical engineering and many articles relating to engineering projects and engineering education. He was a member of many technical societies including The American Society of Mechanical Engineers, the American Society of Civil Engineers, the Institution of Electrical Engineers, and the American Institution of Consulting Engineers, as well as the American Academy of Arts and Sciences, the American Philosophical Society, and the Engineers' Council for Professional Development.

Edward Leyburn Moreland (A '11, M '15, F '21, Member for Life), retired, Boston, Mass., died on June 17, 1951. He was born on July 1, 1885, in Lexington, Va., and was graduated from The Johns Hopkins University in 1905 with a bachelor of arts degree and received a master of science in electrical engineering from the Massachusetts Institute of Technology in 1908. That same year he became a member of the firm of Jackson and Moreland, Boston, Mass., where his work consisted mainly of acting as consulting engineer to public utilities on the design and supervision of construction of power plants, transmission, and distribution systems. During World War I he served as captain and later major of engineers in the American Expeditionary Forces. From 1935 to 1938 he headed the Department of Electrical Engineering at Massachusetts Institute of Technology, Cambridge, Mass. He was Dean of Engineering from 1938 to 1946 when he was named Executive Vice-President. He retired from this post in June 1950. During World War II he served on the National Defense Research Commission and in other consulting capacities. For his services he was awarded the Medal of Freedom by the War Department and the Medal for Merit by the President. He had several books and technical papers published and was active in many engineering societies, including the Engineers' Council for Professional Development and its Committee on Engineering Education. He was a very active member of the AIEE and served on many Institute committees, including the following: Electrical Machinery; Power Generation; Transportation (Chairman 1931–34); Technical Program; Standards (Chairman 1934–36); Education; Institute Policy; Transfers; Lamme Medal; Research; and Management.

Robert Bass Morton (A '18, M '20, F '20, Member for Life), retired, Upper Montclair, N. J., died on May 19, 1951. He was born on March 19, 1878, in Randolph, Vt., and was graduated from the Unversity of Vermont in 1895 with a bachelor of science degree in electrical engineering and from Massachusetts Institute of Technology in 1901 with a degree in electrical engineering Mr. Morton worked for the Manhattan Elevated Railway Company from 1901 to 1905, and then became associated with the Interborough Rapid Transit Company. He began specializing in railway engineering in 1906 when he worked as a consultant for the Hudson and Manhattan Railroad. During World War I he was an appraiser with the Federal Government's Bureau of Aircraft Production, Dayton, Ohio. In 1923 he joined the firm of Gibson Hill, consulting engineers, who did the electrification of the Pennsylvania Railroad and its affiliates.

Ernest Hill Billipp (A '08, M '20, Member for Life), retired, Rye, N. Y., died on June 8, 1951. He was born on May 4, 1882, in Boston, Mass. From 1899 to 1918 he was associated with the Otis Elevator Company as an electrical engineer and manager of foreign branch offices. In 1921, Mr. Billipp became chief electrical engineer for the Warsaw Elevator Company and retained that position until 1926 at which time he became associated with the Turl Iron and Car Company. He was successively general manager and Vice-President of the company. Mr. Billipp was also a member of The American Society of Mechanical Engineers.

Cornelius Ridgley (A '42, M '45), electrical engineer, I-T-E Circuit Breaker Company, Philadelphia, Pa., died on May 18, 1951. He was born on August 2, 1909, in Annapolis, Md., and received a bachelor of science degree in electrical engineering from New York University in 1931. He also took postgraduate work at Lehigh University. Mr. Ridgley became associated with the I-T-E Circuit Breaker Company in 1937 as an electrical engineer and worked with the design and application of low-voltage circuit breakers. He was an active member of the Philadelphia Section of the AIEE, having served as the Chairman of the Prize Paper Committee (1950–51).

MEMBERSHIP

Recommended for Transfer

The board of examiners at its meeting of June 21, 1951, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Fellow

Almquist, C. T., electrical engg. professor, University of Oklahoma, Norman, Okla.
Anderson, A. S., asst. mgr., central station dept., General Electric Co., Denver, Colo.
Barnett, H. G., distribution engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
Burnap, R. S., commercial engg. manager, Radio Corporation of America, Harrison, N. J.
Easton, F. A., electrical engg. professor, University of Colorado, Boulder, Colo.
Hagenguth, J. H., engr., high voltage engg. lab., General Electric Co., Pittsfield, Mass.
Leyland, S. C., manager, protective relay design, Westinghouse Electric Corp., Newark, N. J.
Linney, R. W., transmission & protection engr., Oklahoma Southwestern Bell Telephone Co., Oklahoma City, Okla.
Nielsen, R. A., consulting & application engr., Westinghouse Electric Corp., Los Angeles, Calif.
Osterle, W. H., system planning engr., West Penn Power Co., Pittsburgh, Pa.
Palmer, H. B., electrical engg. professor, University of Colorado, Boulder, Colo.
Pinto, A., chief consulting engr., Otis Elevator Co., New York, N. Y.
Sharp, H., radio engr., The Mountain States Tel. & Tel. Co., Denver, Colo.
Sinclair, D. B., chief engr., General Radio Co., Cambridge, Mass.
Smith, G. S., electrical engg. professor, University of Washington, Seattle, Wash.
Sommerman, G. M. L., assoc. prof. of electrical engg., Northwestern University, Evanston, Ill.

16 to grade of Fellow

To Grade of Member

Anderson, J. J., Jr., asst. to secretary; secretary board of Examiners, American Institute of Electrical Engineers, New York, N. Y.
Barrett, R. D., assoc. engr., Memphis Light, Gas & Water Div., Memphis, Tenn.
Baum, R. S., engg. instructor, University of Pittsburgh, Johnstown, Pa.
Becker, H. I., Jr., section engr., General Electric Co. Erie, Pa.

Beckwith, W. K., asst. power supervisor, Union Electric Co. of Missouri, St. Louis, Mo.

Beggs, G. E., Jr., patent engr., Leeds & Northrup Co., Philadelphia, Pa.

Berry, T. M., section engr., general engg. lab., General Electric Co., Schenectady, N. Y.

Black, T. L., engr., General Electric Co., Johnson City, N. Y.

Bolster, W., head, engg. dept., Sperry Gyroscope Co., Great Neck, N. Y.

Bracken, J. M., electrical div. supervisor, American Viscose Corp., Philadelphia, Pa.

Britt, F. L. (Miss), research physicist, Corning Glass Works, Corning, N. Y.

Brooks, G. E., circuit breaker & protection specialist, Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Brotzman, E. S., manager, factory engg., Philco Corp., Philadelphia, Pa.

Campbell, V. P., manager, public utility district #1, Newport, Wash.

Carl, W. C., industry engr., Westinghouse Electric Corp., East Pittsburgh, Pa.

Carolus, J. B., supervising engr., Leeds & Northrup Co., Philadelphia, Pa.

Carpenter, H. E., division supt., western div., Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Coolidge, A. W., Jr., engr., General Electric Co., Schenectady, N. Y.

Criddle, F. P., sales engr., General Electric Co., Seattle, Wash.

DeFriaco, J. A., design engr., American Viscose Corp., Philadelphia, Pa.

DeWitt, D., director of research, Radio Receptor Co., Inc., Brooklyn, N. Y.

Dixon, M. H., power engr., St. Regis Paper Co., Deferiet, N. Y.

Dolasa, S. R., manager, The Associated Cement Cos. Ltd., Kymore, Jukehi, India

Duff, J. C., elec. design engr., Reliance Electric & Engineering Co., Cleveland, Ohio

Eaton, G. O., district engr., New England Power Service Co., Malden, Mass.

Edwards, A. W., section mgr., Westinghouse Electric Corp., East Pittsburgh, Pa.

Ellison, J. R., relay foreman, system labs., Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Ferrara, C., acting director, elec. engg. dept., University of Detroit, Detroit, Mich.

Flath, E. H., Jr., electronic scientist, Naval Research Lab., Washington, D. C.

Forsberg, A. W., vice pres. & engineer, Gaveco Laboratories, Inc., New York, N. Y.

Freeman, B., asst. supv., telegraph & signals, Pennsylvania Railroad, Pittsburgh, Pa.

Freeman, C. F., chief elec. engr., Messrs. Courtaulds Ltd., Coventry, England

Friedman, E. D., chief engr., specialty engg. div., Specialty Assembling & Packing Co., Brooklyn, N. Y.

Garnett, L. D., application engr., I-T-E Circuit Breaker Co., Chicago, Ill.

Gerlough, D. L., asst. engr., University of California, Los Angeles, Calif.

Gershberg, J., mechanical engr., Gibbs & Hill, Inc., New York, N. Y.

Gerwing, T. G., master design engr., regulator sec., Westinghouse Electric Corp., Sharon, Pa.

Gibson, H., application engr., industrial engg. div., General Electric Co., Schenectady, N. Y.

Gifford, F. A., radio transmission engr., New England Tel. Tel. Co., Boston, Mass.

Glaser, E. M., senior elec. engr., Kollman Instrument Corp., Elmhurst, N. Y.

Goetz, J. A., Jr., technical resident engr., International Business Machines, Inc., Poughkeepsie, N. Y.

Goodridge, H. L., asst. engr., New England Power Service Co., Boston, Mass.

Greene, R. B., electrical engr., Rural Electrification Administration, Washington, D. C.

Guyer, E. M., research physicist, Corning Glass Works, Corning, N. Y.

Harrington, D. B., generator engg. div., General Electric Co., Schenectady, N. Y.

Haviland, R. P., section engr., General Electric Co., Schenectady, N. Y.

Hemstreet, J. G., general system operations supervisor, Consumers Power Co., Jackson, Mich.

Hildebrand, R. L., Commander, U. S. Navy, Washington, D. C.

Hill, C. R., electrical engr., U. S. Bureau of Reclamation, Boulder City, Nev.

Hunt, F. B., assistant engr., New England Power Service Co., Boston, Mass.

Impelliteri, V. J., electrical engr., Bureau of Ships, Washington, D. C.

Johnta, T. E., application engr., apparatus dept., General Electric Co., Chicago, Ill.

Jones, R. J., instructor, elec. engg. dept., Michigan College of Mining & Technology, Houghton, Mich.

Judkins, H., elec. engr., General Electric Co., Pittsfield, Mass.

Karcher, E. R., electronics engr., Consolidated Vultee Aircraft Corp., San Diego, Calif.

Kilman, L. B., research engr., Hughes Aircraft, Culver Calif.

Kirk, C. B., Jr., engr., The Chesapeake & Potomac Tel. Co. of Virginia, Richmond, Va.

Kowal, C. F., senior design engr., The Louis Allis Co., Milwaukee, Wis.

Larew, J. J., development engr., General Electric Co., Schenectady, N. Y.

Leigh, C. T., electrical engr., New Bedford Rayon Co., New Bedford, Mass.

Linowieckl, A. G., engr., Sverdrup & Parcel, St. Louis, Mo.

Linsenmeyer, J. Z., mgr., mining, petroleum & chemical sec., Westinghouse Electric Corp., East Pittsburgh, Pa.

Lobosco, R. R., development engr., Lir de Air Products Co., Newark, N. J.

Luginbill, W. F., dist. plant supt., Michigan Bell Telephone Co., Traverse City, Mich.

Magechon, O., asst. area engr., General Electric Co., Richland, Wash.

Mahn, G. R., electrical engr., vacuum tube dev. lab., General Electric Co., Milwaukee, Wis.

Mapp, F. J., equipment engr., New England Tel. & Tel. Co., Boston, Mass.

McCollum, W., production control & planning engr., Dow Chemical Co., Midland, Mich.

Metz, A. W., development engr., Weston Electrical Instrument Corp., Newark, N. J.

Monson, D. J., electrical engg. instructor, University of California, Berkeley, Calif.

Moody, H. S., electrical engr., Clayton T. Gibbs, C. E., Los Angeles, Calif.

Moody, R. R., partner, McWhorter, Robinson & Moody, Staunton, Va.

Moore, A. H., application engr., General Electric Co., New York, N. Y.

Moore, C. R., electrical designer, American Viscose Corp., Philadelphia, Pa.

Morris, J. C., electrical service engr., Westinghouse Electric Corp., Dallas, Tex.

Morrow, R. O., partner, Linn O. Morrow & Son, Philadelphia, Pa.

Mueller, J. W., electrical engr., U. S. Bureau of Reclamation, Sacramento, Calif.

Myers, J. E., mgr., apparatus dept., General Electric Co., Columbia, S. C.

Niemoeller, E., toll services transmission engr., The Pacific Tel. & Tel. Co., Los Angeles, Calif.

Niemark, T., assoc. electrical engr., Commonwealth Services, Inc., Jackson, Mich.

Noble, H. P., Jr., district supt., Virginia Electric & Power Co., South Boston, Va.

Olsen, S. R., asst. electrical engr., Pioneer Service & Engineering Co., Chicago, Ill.

Oppermann, R. H., electrical engr., Associated Factory Mutual Fire Insurance Cos., Philadelphia, Pa.

Orellana, I. G., project engr., Republic Steel Corp., Cleveland, Ohio

Palmrose, E. W., mechanical engr., Southern California Edison Co., Los Angeles, Calif.

Peterson, W. H., asst. engr., Pacific Gas & Electric Co., San Francisco, Calif.

Potthoff, E. O., application engr., General Electric Co., Schenectady, N. Y.

Price, J. C., transportation industry engr., General Electric Co., Schenectady, N. Y.

Puterbaugh, W. H., Jr., electrical engr., National Cash Register Co., Dayton, Ohio

Radford, R. A., associate engr., Utah Power & Light Co., Salt Lake City, Utah

Rey, W. A., general foreman, Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Richardson, W. A., secy.-treas.; chief electrical engr., Henningson, Durham & Richardson, Inc., Omaha, Nebr.

Riechers, T. W., senior relay engr., Northern Indiana Public Service Co., Hammond, Ind.

Ritchie, J. A., assoc. engr., Virginia Electric & Power Co., Richmond, Va.

Robinson, W. P., Jr., elec. engr., Kuljian Corp., Philadelphia, Pa.

Rooney, F. H., plant engr., Ironton Plant & Geneva Steel Co., Provo, Utah

Roseberry, C. V., mgr. central station dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Roumanis, P. J., application engr., General Electric Co., Philadelphia, Pa.

Scheibe, E. H., instructor, University of Wisconsin, Madison, Wis.

Schimke, C. F., chief engr., Porcelain Products, Inc., Parkersburg, W. Va.

Shaffer, W. B., chief engr., Power Equipment Co., Detroit, Mich.

Shankle, D. F., headquarters central station engr., Westinghouse Electric Corp., East Pittsburgh, Pa.

Smith, C. A., chief electrical operator, Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Smith, H. W., western div. engr., Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Spellmire, G. W., asst. supt. electrical installations General Electric Co., Chicago, Ill.

Stephenson, S. S., Jr., elec. engg. instructor, Manhattan College, New York, N. Y.

Stockwell, G. A., research lab. supervisor, dept. of water power, Chief, Los Angeles, Calif.

Stone, S. F., senior asst. elec. engr., Public Lighting Comm., Detroit, Mich.

Stone, W. T., electronic engr., Public Works Dept., Norfolk, Va.

Strode, V. C., design engr., General Electric Co., Schenectady, N. Y.

Sublette, M. C., application engr., General Electric Co., Schenectady, N. Y.

Taylor, G. H., asst. product engr., Sperry Gyroscope Co., Great Neck, N. Y.

Tarlo, R., asst. chief elec. engr., Homestake Mining Co., Lead, S. D.

Taylor, G. H., asst. product engr., Sperry Gyroscope Co., Great Neck, N. Y.

Tienken, W. J., Jr., asst. sales mgr., Morganite Inc., Long Island City, N. Y.

Turner, E. A., engr., New England Power Service Co., Boston, Mass.

Veronda, C. M., senior project engr., Sperry Gyroscope Co., Great Neck, N. Y.

Waldron, C. J., elec. engr., Rural Electrification Administration, Washington, D. C.

Walthers, E. R., requisition engr., General Electric Co., Schenectady, N. Y.

Weiss, W. A., plant mgr., Sylvania Electric Products, Inc., Emportum, Pa.

White, P. V., asst. mgr., oilostatic dept., Okonite Callender Cable Co., Paterson, N. J.

Willennar, A. H., acting chief system production coord. group, American Gas & Electric Service Corp., Columbus, Ohio

Wilson, J., elec. engr., Tennessee Valley Authority, Knoxville, Tenn.

Wilson, R. C., toll service supervisor, The Pacific Tel. & Tel. Co., Los Angeles, Calif.

Wilson, R. M., Jr., application engr., General Electric Co., Schenectady, N. Y.

Witzig, W. F., senior engr., Westinghouse Atomic Power Division, Pittsburgh, Pa.

Youngdahl, C. H., supt. of electrical operation, U. S. Steel Co., Chicago, Ill.

Zajac, A., senior office asst., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.

128 to grade of Member

Applications for Election

Application for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before August 25, 1951, or October 25, 1951, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Anderson, H. V., Anderson Elec. Co. Ltd., Flin Flon, Manitoba, Canada

Ani, D. A. O., c/o Messrs. Malcolm & Allen, London, England

Badkas, D. J., Indian Institute of Science, Bangalore, S. India

Brown, W. B., Canadian General Elec. Co., Peterborough, Ont., Canada

Chipman, E. J., The Austin Co., Houston, Tex.

Croco, C. P., Westinghouse Elec. Corp., Buffalo, N. Y.

Cronin, M. J. J., Bristol Aeroplane Co., Filton, Bristol, England

Dailey, H. J., Westinghouse Elec. Corp., Bloomfield, N. J.

DeHeem, L. M. P., Societe pour la Coordination de la Production et du Transport de l'Energie electrique, Brussels, Belgium

de Luccia, E. R., Federal Power Comm., Washington, D. C.

Demeny, M. G., Electric Specialty Co., Stamford, Conn.

Eberline, H. C., University of California, Los Alamos, New Mex.

Elg, G. W., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.

Fister, F. M., Southern Bell Tel. & Tel. Co., Columbia, S. C.

Gratzscheid, I. J., Faruk I University, Alexandria, Egypt

Gray-Donald, E. D., The Shawinigan Water & Power Co., Montreal, Que., Canada

Hirsch, R. J., Shawinigan Water & Power Co., Shawinigan Falls, Que., Canada

Hunter, D. A., Chesapeake & Potomac Tel. Co., Washington, D. C.

Ingram, W. W., Shawinigan Water & Power Co., Shawinigan Falls, Que., Canada

Kasner, E., Utility Electronics Corp., Newark, N. J.

Kern, G. F., American Tel. & Tel. Co., New York, N. Y.

Kutscher, R. H., Electric Machinery Mfg. Co., Minneapolis, Minn.

Leibel, N., Ministry of Transport & Communications, State of Israel, Jaffa, Israel

Long, F. H., Eastern Elec. Board, Enfield, Middlesex, England

Lucek, J. G., J. E. Redmond Supply Co., Phoenix, Ariz.

Mahmoud, A. A., Fouad University, Giza, Cairo, Egypt

Markowitz, O., U. S. Naval Air Development Center, Johnsville, Pa.

Meyirott, G. W., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.

Millikin, A. D., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

Mulvany, H. A., 720 Channing Way, Berkeley, Calif.

Mutdogan, A. G., Turkish Govt., Ministry of Public Works, Ankara, Turkey, c/o U.S.B.R., Denver, Colo.

Nelson, E. M., Nelson Elec. Co., El Paso, Tex.

Parrymore, C. S., South African Railways & Harbours, Langlaagte, Johannesburg, South Africa

Peterson, A. P. G., General Radio Corp., Cambridge, Mass.

Pierce, D. L., Westinghouse Elec. Corp., Buffalo, N. Y.

Richardson, J. M., Power Corp. of Canada Ltd., Montreal, Que., Canada

Roschke, T. H., Jr., Western Cartridge Co., East Alton, Ill.

Salin, J. A., Ebasco Services, Inc., New York, N. Y.

Shuman, M. M. (re-election), Moloney Elec. Co., Alexandria, Va.

Smith, G. W., Garthorne, Buonaccorsi & Murray, San Francisco, Calif.

Steger, L. O., Potomac Electric Power Co., Washington, D. C.

Tampier, F., Consumers Power Co., Jackson, Mich.

Wayne, C. R., General Elec. Co., Syracuse, N. Y.

Whittaker, C. C., Westinghouse Elec. Corp., E. Pittsburgh, Pa.

Willby, N. H., Westinghouse Elec. Corp., E. Pittsburgh, Pa.

Wollman, J. R., Sverdrup & Parcel, Inc., St. Louis, Mo.

Zeth, A. M., Railway & Industrial Engineering Co., Greensburg, Pa.

47 to grade of Member

Report of the Board of Directors

THE BOARD OF DIRECTORS of the American Institute of Electrical Engineers presents to the membership its 67th annual report, covering the fiscal year ending April 30, 1951. It contains a brief summary of the principal activities of the Institute during the year, a general balance sheet showing the financial condition of the Institute at the close of the fiscal year, a statement of cash receipts and disbursements, and a schedule of securities owned. Much additional information regarding the activities appeared in various issues of *Electrical Engineering*.

BOARD OF DIRECTORS' MEETINGS

Five meetings of the Board of Directors were held during the year, two in New York, N. Y., one each in Pasadena, Calif., Oklahoma City, Okla., and Miami Beach, Fla.

Information regarding many of the more important matters which were considered by the Board of Directors appeared in various issues of *Electrical Engineering*.

INSTITUTE POLICY

A report on the 1949 Membership Opinion Poll and a progress report on the membership voting on the following three proposals of policy were published in the 1950 Board of Directors report:

1. To work continually for the unification of the profession.

2. To recognize the fact that the Institute finds its chief reason for existence in the technical field.

3. To handle questions on nontechnical affairs as necessary and as they arise, on an emergency basis, until through unification they can be handled on a general professional basis.

The votes to June 1, 1950, are reported here:

Proposal	Number 1	Number 2	Number 3
Approved	4,062	4,077	4,012
Disapproved	321	349	383

The Board of Directors, at its meeting on June 15, 1950, directed that the tabulation on the 1950 poll be published in *Electrical Engineering*, with the conclusion that the membership, as represented by the poll, endorses the three proposals, and a statement to the effect that the Board of Directors of the AIEE will, therefore, be guided by these three proposals in making all of its decisions concerning Institute activities (*EE, Aug '50, p 669*).

INSTITUTE VISITS

For several years, the Board of Directors has been endeavoring to relieve the President of responsibility for Section visits, and to place this responsibility upon the Vice-Presidents. A resloution to this effect was adopted on June 27, 1946, and appears on page 510 of the 1950 Year Book.

After further discussion at various times, and particularly on April 27, 1950, the Board of Directors took the following action on that date:

VOTED that it is the sense of the Board of Directors that the President should not be expected to visit Sections or Branches; that those official visits should be made the responsibility of the Vice-Presidents, with the cooperation of Directors, or District Secretaries, or other Institute personnel who may be designated by the Vice-Presidents; and that the President concentrate his attention on general and District meetings, technical conferences, and such other meetings as should, in his discretion, be attended; also that this action be transmitted to all Sections, and that the Finance Committee be requested to make provisions in the 1950–51 budget for such visits.

President LeClair visited certain Sections and attended the general and District meetings. He also attended meetings of the Engineers Joint Council, and represented the Institute at several meetings of various types. The Vice-Presidents visited substantial percentages of the Sections within their Districts, and also many Student Branches.

ANNUAL MEETING

The 66th annual business meeting of the Institute was held in Pasadena, Calif., June 12, 1950. The annual report of the Board of Directors for the fiscal year which ended April 30, 1950, was presented in abstract by Secretary H. H. Henline, who also presented a report of the Committee of Tellers on the vote of the membership on the election of officers whose terms were to begin on August 1, 1950. In the absence of the Treasurer, W. I. Slichter, Secretary Henline also presented a brief report of the Treasurer. President-elect Titus G. LeClair was introduced, and responded with a brief address covering broadly the problems ahead, both in the Institute and in its relations with other organizations.

In commemoration of the 100th anniversary of the birth of Oliver Heaviside, an address was given by Dr. Paul S. Epstein, Professor of Theoretical Physics at the California Institute of Technology since 1921.

The Lamme Medal for 1949 was presented to C. M. Laffoon, Manager of the A-C Engineering Department, Westinghouse Electric Corporation.

Mr. Fairman delivered a message of great importance to the engineering profession in his President's address, "Is Engineering a Profession?"

GENERAL MEETINGS

Three general meetings were held during the year, and a brief report on each follows:

Summer and Pacific General Meeting. The 66th Summer General Meeting was combined with the Pacific General Meeting and held in Pasadena, Calif., June 12–16, 1950, with a registration of 1,665. The program included 31 technical sessions and conferences, an opening ceremony, the annual business meeting of the Institute, ten committee meetings, two Section Delegates sessions, conference of Vice-Presidents and District Secretaries, meeting of the Board of Directors, two student technical sessions, session for presentation of District Branch Prize Papers, numerous inspection trips, banquet, aquacade, and President's Reception, and an extensive schedule of events for the ladies.

Fall General Meeting. The Fourth Fall General Meeting was held in Oklahoma City, Okla., October 23–27, 1950, with a registration of 1,144. In 25 technical and conference sessions 122 papers were presented. Other events were a Forum of Technical Committee Chairmen, 15 committee meetings, general session, meeting of the Board of Directors, meeting of the South West District Executive Committee, joint luncheon with the Oklahoma City Chamber of Commerce, dinner-dance, stag smoker, inspection trips, and a special program for the ladies.

Winter General Meeting. The Winter General Meeting was held in the Hotel Statler, New York, January 22–26, 1951, with the largest program in the history of the Institute, and a registration of 3,334. There were 67 technical sessions, in which 143 formal papers and 160 conference papers were presented. At three general sessions, the Hoover, John Fritz, and Edison Medals were presented. After receiving the Hoover Medal, Dr. Karl T. Compton gave an address on "Engineers and National Security." The Alfred Noble prize and numerous AIEE prizes for papers were presented. Other parts of the meeting were a meeting of the Board of Directors, Forum of Technical Committee Chairmen, 100 committee meetings, smoker, dinner-dance, numerous inspection trips, and special events for the ladies.

DISTRICT MEETINGS

Great Lakes District Meeting. In a 2-day meeting of the Great Lakes District, in Jackson, Mich., May 11–12, 1950, the principal subject was "Transmission and Distribution of Electric Energy on Systems with Low Load Density." Many of the papers in seven technical sessions were directly related to this subject. Other events were a general session, two student sessions in which the Branch Prize winners presented their papers, graduate student session, informal banquet, student banquet, inspection trips, and several features for the ladies. The registration was 536.

Middle Eastern District Meeting. A Middle Eastern District Meeting was held in Baltimore, Md., October 3–5, 1950, with a registration of 972. In 23 sessions 98 papers were presented. In addition, there were a general session on the topic "Developing Engineers for Industry," smoker, cabaret dance, inspection trips, and ladies' events. The Executive Committee of District 2 held an all-day meeting on the day preceding the District Meeting.

Southern District Meeting. A Southern District Meeting was held in Miami Beach, Fla., April 11–13, 1951. The program included a general session with an address by President LeClair, four technical sessions at which 34 papers were presented, a meeting of the Board of Directors, several inspection

and sight-seeing trips, luncheon, banquet, buffet and water show, and a program of events for the ladies. The registration was 421.

SPECIAL TECHNICAL CONFERENCES

"Special Technical Conferences" were inaugurated in 1948, and have proved so successful that they are now planned and conducted as a regular Institute activity. The conferences are intended to be national in interest, technical in character, and concentrated as to subject matter toward one particular industry or objective. This type of meeting is designed to explore thoroughly a limited field and to afford specialists in that field an opportunity to discuss mutual technical problems. The conference may be defined as a program of panel discussions, technical papers, or exhibits under the auspices of a national technical committee, in cooperation with an AIEE local Section, which might act as host to the conference. Operating under the policy and procedure which has been set up, the following conferences were held during the past fiscal year:

Rubber and Plastics Conference. The third annual conference on electrical engineering problems in the rubber and plastics industries was held in Akron, Ohio, May 5, 1950, sponsored by the Subcommittee on Rubber and Plastics Industries of the Committee on General Industry Applications in co-operation with the Akron Section. A diversified program was planned to attract as large an attendance as possible. This resulted in the presentation of eight papers. Some of the subjects covered were calender auxiliary drives, including constant tension winder drives for film and fabric; recent developments in process sequence control; electrostatic casualties in the rubber and plastic industries; and so forth. The conference was attended by 173 persons. No proceedings were published.

Improved Quality Electronic Components Conference. A 3-day conference was held in Washington, D. C., May 9–11, 1950, sponsored by the AIEE, Institute of Radio Engineers, and Radio Manufacturers Association, with active participation by agencies of the United States Department of Defense and the National Bureau of Standards. The main theme of this conference was that components for military electronic equipment must be designed to serve without replacement during the normal life of the equipment if electronics is to continue in its role of increasing importance in modern warfare. The conference was attended by 749 engineers and scientists from all parts of the United States, as well as representatives from Canada, Great Britain, Australia, New Zealand, and Sweden. The five sessions covered dependability in electronics, unitized design and electronic fabrication techniques, components, and panel discussion. During the conference there were also several interesting inspection trips. A complete report of the conference, including papers and discussions, has been prepared and is available at $3.50.

Telemetering Conference. The Philadelphia Section was host to a 3-day telemetering conference in Philadelphia, Pa., May 24–26, 1950, sponsored by the AIEE and the National Telemetering Forum. In conjunction with the conference, eight exhibitors demonstrated their telemetering products in the display room of the Philadelphia Electric Company. The attendance was 205. Two inspection trips were arranged to the Franklin Institute Laboratories for Research and Development and the Raymond Rosen Engineering Products, Inc. Both point-to-point and mobile telemetering were covered at this conference. The five sessions were devoted to general features of telemetering, telemetering systems, telemetering systems and pickups, data presentation, and other topics, including definitions of telemetering terms. Complete proceedings of the conference have been printed in book form and are available at AIEE headquarters at $3.50 per copy.

Domestic Appliances Conference. A conference on domestic appliances was held in Cleveland, Ohio, June 20, 1950, sponsored by a special subcommittee of the Committee on Domestic and Commercial Applications, in co-operation with the Cleveland Section. There was an attendance of 86. The morning session was devoted to automatic washing machines, and the afternoon session was given to electric ranges. During the discussion period, problems of motor drives, controls, and other accessories were covered. Due to the enthusiasm of those attending, the committee is planning to promote such a conference next year as part of its activity.

Conference on Electronic Instrumentation in Nucleonics and Medicine. The third annual joint conference on electronic instrumentation in nucleonics and medicine, sponsored by the AIEE and the Institute of Radio Engineers, was held in New York, N. Y., October 23–25, 1950, with 653 people attending. The first day of the 3-day conference featured papers on subjects in the non-nucleonic phases of electronics in medicine. The second day was devoted to nucleonics and medicine. The last day covered nucleonic development in industry and government laboratories. There were six sessions with a total of 23 papers presented, plus a round-table discussion on the evening of the second day on the subject "Effects of Atomic Weapons." Exhibits of nucleonic apparatus, instruments, and components were shown by 20 manufacturers. No conference proceedings were published.

Machine Tools Conference. The third annual conference on machine tools was held in Worcester, Mass., November 14–16, 1950, sponsored by the AIEE Subcommittee on Machine Tools of the Committee on General Industry Applications and the Worcester Section. The total attendance was more than 200. During the morning session of the first day four papers were presented. The afternoon was devoted to plant visitations in and around Worcester, Mass. Six papers were presented on the second day, and there was a meeting of the Subcommittee on Machine Tools. The subcommittee unanimously considered the conference very successful and made plans for holding future conferences on this subject. Approximately 150 conferees went to Springfield, Vt., for the final day of the conference, which was spent visiting four machine tool plants in the Windsor-Springfield area. No conference proceedings were published.

Electron Tubes for Computers Conference. A conference on electron tubes for computers was held in Atlantic City, N. J., December 11–12, 1950, sponsored by the AIEE and Institute of Radio Engineers, in collaboration with the Panel on Electron Tubes of the Research and Development Board. It was attended by 316 engineers from all parts of the country and from Canada and England. This conference was the result of a survey which indicated that the field of electron tubes for computers was in need of clarification. The sessions included computer experience with electron tubes; electron tube problems; special purpose computer tubes; tube manufacture and crystal diode experience; and Williams type storage. No proceedings were published.

Conference on High-Frequency Measurements. The second conference on high-frequency measurements was held in Washington, D. C., January 10–12, 1951, jointly sponsored by the AIEE, Institute of Radio Engineers (IRE), and National Bureau of Standards. It was evidenced at this second conference that the radio-frequency portion of the spectrum is in a state of expansion. After registration, the members of the conference were invited to the Bureau of Standards where open house was held on Wednesday morning. Here the guests were shown the research and experiments being conducted in magnetism and electricity towards the goal of establishing various constants with a greater accuracy. The sessions were devoted to measurements of frequency and time; measurements of impedance; measurements of power and attenuation; and measurements of transmission and reception. An evening demonstration session also was held. Inspection trips were arranged to the National Bureau of Standards, the Naval Observatory, the Naval Ordnance Laboratory, and the Naval Research Laboratory. There was a total attendance of 549 engineers from all parts of this country and Canada. No conference proceedings were published.

As this was the 50th anniversary of the National Bureau of Standards, President T. G. LeClair of AIEE and President I. E. Coggeshall of IRE presented scrolls to Dr. E. U. Condon, Director of the National Bureau of Standards, at this conference.

Textile Industry Conferences. Two conferences on the textile industry were held in April 1951. The first was held in Philadelphia, Pa., on April 23, on the subjects of static electricity in the textile process and electrical installation practice and problems, and was sponsored jointly by the AIEE Textile Industry Subcommittee of the Committee on General Industry Applications, the Philadelphia Textile Institute, and the Philadelphia Section of AIEE. Papers presented covered principles of static electricity, electric installations on full-fashioned hosiery machines, and so forth. The attendance was 84. The second conference was held in Atlanta, Ga., on April 26 and 27, and also covered static electricity, with the addition of textile mill power systems and maintenance. It was co-sponsored by the Textile Industry Subcommittee, Georgia Institute of Technology, and the Georgia Section of AIEE. Some of the interesting subjects discussed were: static in the woolen industry, design of a textile mill power system, and problems in operation and maintenance of a mill power system. The attendance was 140. No proceedings are to be published.

GENERAL COMMITTEES

BOARD OF EXAMINERS

Board meetings were well attended, and consequently no meetings other than those regularly scheduled were required. In addition to its regular work, the Board prepared a rough draft of proposed amendments to the Constitution relative to the revision of membership classification to conform to the suggested uniform membership grades prepared by the Engineers' Council for Professional Development committee on that subject. This draft was submitted to the Committee on Constitution and By-Laws for preparing the amendments in proper form for the Board of Directors.

Statistics relating to the number of cases handled by the Board are given in Table I. The current total, excluding those enrolled as Student members, is more than 17 per cent greater than in 1949–50. This is largely due to a more than 22 per cent increase in the number of Associate applications. Large Student enrollments of previous years probably account for most of this increase in Associates.

Student enrollment for the current year is more than 35 per cent under that of 1949–50. This is accounted for in large part by the closing out of the GI Bill of Rights and the current build-up of the armed forces.

COMMITTEE ON CODE OF PRINCIPLES OF PROFESSIONAL CONDUCT

The "Statement of Principles of Professional Conduct," which last year's annual report stated was almost complete, was approved by the Board of Directors on August 4, 1950, and published in the Year Book, pages 491–3, and in the February issue of *Electrical Engineering*, pages 171–3.

Since that time there has been only one request for any committee action concerning the Principles as published. That request was for a clarification of Section 27 of the Code, which reads: "He will not use the advantages of a salaried position to compete unfairly with other engineers."

The chairman replied to that request by stating that in his opinion the rule means that engineers who have positions that provide office space or other emoluments should not take advantage of such favors and charge fees for consultations less than the regular charges made by consulting engineers practicing in the region involved.

COMMITTEE ON CONSTITUTION AND BY-LAWS

This committee submitted certain recommendations to the Board of Directors in advance of the meetings, and the By-Laws were amended as follows:

April 27, 1950. The Board "VOTED to adopt in principle the recommendation for elimination from the By-Laws of all provisions for ex-officio memberships, and to instruct the Committee on Constitution and By-Laws to implement this action." This idea is being carried out in any changes that are being made in the By-Laws.

June 15, 1950. A change was made in Section 1 of the By-Laws, clarifying and restricting the use of Institute badges and imprints of the badges.

Section 76 of the By-Laws also was revised, changing the composition of the Committee on Award of Institute Prizes.

Table I. Applications for Admission and Transfer, 1950–1951

Applications for Admission			
Recommended for grade of Associate	4,670		
Re-elected to grade of Associate	77		
Not recommended	8	4,755	
Recommended for grade of Member	315		
Re-elected to grade of Member	17		
Not recommended	48	380	
Recommended for grade of Fellow	6		
Reinstatement to grade of Fellow	2		
Not recommended	3	11	
Applications for Transfer			
Recommended for grade of Member	575		
Not recommended	22	597	
Recommended for grade of Fellow	159		
Not recommended	3	162	
Students			
Recommended for enrollment as Students		4,988	
Total			10,893

August 4, 1950. Section 53 of the By-Laws was amended, raising the Student dues to $5.00 per year.

October 26, 1950. Sections 33, 51, 53, 60, and 84 of the By-Laws, covering Student Branches, were amended to facilitate the operation of the Branches and enable them to complete their organization earlier in the year.

January 25, 1951. This committee recommended certain changes in the Constitution which would transfer the dues and entrance and transfer fees from the Constitution to the By-Laws.

It was recommended that all of Article II of the Constitution and parts of Articles III and IV be revised to establish uniform grades of membership as recommended by Engineers' Council for Professional Development. This recommendation limits the elevation to the grade of Fellow to the method known as proposal by invitation, to be extended by the Board of Directors. It changes the Associate grade to Associate Member and adds a new grade to be known as Affiliate.

A number of minor changes in the Constitution were also recommended to take care of the new grades of membership. The Board approved these proposed amendments to the Constitution, subject to corrections by legal counsel, for submission to the membership for vote. Recommendations were also made and approved for making the corresponding changes in the By-Laws, contingent upon adoption of the Constitutional amendments by the membership.

COMMITTEE ON EDUCATION

During the past year the committee sponsored two conference sessions at general meetings. At the Summer General Meeting, the theme of the conference was "Planning of New Laboratory Facilities." The theme was dealt with by three separate papers, written by well-known authorities in electrical engineering education, describing the planning and the actual facilities included in new laboratory buildings. The session was timely, since a great deal of new construction is currently under way at the engineering colleges, and many of the novel features discussed at the session have been helpful to others in their planning.

At the Winter General Meeting, a conference session on "Graduate Study in Electrical Engineering" was presented. Three papers on various phases of graduate study were presented, each of which discussed distinctly different phases of the graduate curriculum. The session was very well attended, and its timeliness was attested to by the fact that discussion continued from both educators and representatives of industry until it was necessary arbitrarily to terminate the meeting. Also at the Winter General Meeting, the committee acted as joint sponsor at a conference session on electronic education. The papers presented discussed the importance of electronic education from the standpoint of industry, of research, and of the academic field itself.

During the year four subcommittees were appointed to study specific subjects believed to be of current importance. They are: Subcommittee on Graduate Programs in Electrical Engineering, Subcommittee on Accrediting of Curricula, Subcommittee on Specific Objectives of Electrical Engineering Curricula, and Subcommittee on Measurement of Educational Effectiveness. The first three of these subcommittees have actively begun their work. The session held at the Winter General Meeting was sponsored by the first of these subcommittees, and future programs are now being planned as a result of the productive efforts of the other subcommittees.

No sessions are planned for the Summer General Meeting because that meeting conflicts directly with the Annual Meeting of the American Society for Engineering Education.

FINANCE COMMITTEE

With a continuing growth in membership, both the income and the expenses of the Institute increase each year. The growth of expenses was accelerated sharply a few years ago due to the rising costs of most things after the end of World War II. The measures mentioned in previous annual reports were put into effect in an attempt to step up the rate of growth of income to compensate for the accelerated growth of expenses. The unavoidable delays before these measures became effective resulted in substantial deficits during the fiscal years ending April 30, 1948, and 1949. The fiscal year ending 1950 showed income and expenses substantially in balance, and, for the year ending April 30, 1951, there was a margin of income over expenses. This recovery was accomplished, however, at the expense of some curtailment in the services to members and a severe limitation upon the volume of technical publications. A continuation of these restrictions is considered undesirable.

If further increases in unit costs take place, another series of deficits can be expected unless it is possible to adjust income more promptly. Since an amendment to the Constitution increasing the dues would require approximately two years to become effective, the Finance Committee recommended to the Board of Directors on October 26, 1950, that the dues provisions be removed from the Constitution and placed in the By-laws. The Board approved this proposal, and, on February 28, 1951, ballots were mailed to the entire membership covering the necessary amendment to the Constitution.

The Finance Committee made an analysis of income and expenses of the Institute, which was published in *Electrical Engineering*,

December 1950, to give the members a clearer understanding of the financial problems of the organization preparatory to the submission of the constitutional amendment.

The amendment of the Social Security Act about the middle of 1950 made it possible for the first time for employees of the Institute to be covered by social security, provided the Board of Directors approved and at least two-thirds of the employees elected to be covered. The Board approved and the necessary two-thirds of the employees voted to be covered. Coverage was made effective as of April 1, 1951.

The financial report for the fiscal year is included in this annual report.

HEADQUARTERS COMMITTEE

The program of modernization of the lighting at AIEE headquarters, started two years ago, has been completed. All office space and the Board of Directors' Room are now equipped with modern fluorescent fixtures with a marked improvement in illumination.

Linoleum floor coverings in rooms 1005, 1007, 1008, and 1009 had deteriorated over the years to such an extent that replacement was necessary, and new linoleum was installed in these rooms during the winter.

Other items in the budget included minor repairs to upholstered chairs in the Members' Room and the Board of Directors' Room, cleaning of draperies, and servicing of air-conditioning units.

There is a slight blistering of the veneer wall covering in the Members' Room and Board of Directors' Room. Repairs were considered, but the price seemed to be too high to warrant any action at this time, as the blisters are not obvious. When this condition becomes objectionable, repairs or refinishing of these rooms will be necessary.

COMMITTEE ON MANAGEMENT

Recognizing the increasing importance of the knowledge of management know-how to electrical engineers, the committee has planned a series of conference programs on this general subject at general and District meetings. These programs will cover the broad field of management, including organization, personnel relations, human relations, government and business, productivity and economy of operations, and related subjects.

The first meeting of the series was held in connection with the Winter General Meeting. William B. Maloney, Manager of Employee Relations Department of The Esso Standard Oil Company, spoke on "Management Development." Mr. Maloney pointed out the need for top-flight management in the future to cope with business competition, the maintenance of excellent management relations with stockholders, employees, customers, and the general public. He also stressed the need for maintaining the type of management personnel which would be capable of assuming active and affirmative leadership in participation in national and community issues, even though these issues were only indirectly related to the problems of business.

In order to achieve a continuing top-flight management, Mr. Maloney suggested a program which included planning the future organizational structure, making an inventory of personnel for management positions, and the training of replacements for management jobs required to be filled in the future. He also pointed out the necessity of recognizing that business philosophies, techniques, and experiences are not static, and that current management personnel requires information to keep pace with the times. This is not only for the purpose of effective management teamwork but also for the purposes of morale values and application of company philosophies and policies to employees. This can be accomplished through 2-way communication between "firing-line" management and executive management and through formalized training.

General Leslie B. Simon, Chief of Ordnance Research and Development Division of the Army, spoke on "An Outline of Army Ordnance Research and Development." General Simon described the intricate and highly organized network of research and development agencies which extends on the one hand all the way up through the General Staff, the Research and Development Board of the Secretary of Defense, to the President as Commander in Chief, and on the other hand down to the laboratories and proving ground in the field. He pointed out that today research and development is a highly organized co-operative process, and he stressed the teamwork between the Ordnance Department and industry and science.

COMMITTEE ON MEMBERS-FOR-LIFE FUND

After a long discussion at a meeting on January 23, the committee unanimously agreed that, with the uncertain conditions now existing, it was undesirable to increase the expenditures of this committee, and therefore voted to recommend that the activities be continued as they have been in the past: considering only the odd-numbered districts one year and the even-numbered districts the next year.

At the time of the meeting, there was available $5,373.00 in cash, with the major expenditures for the year having been made, and none of the income from the members for the year 1950–51 having yet been credited to the account. This would indicate that by the end of the fiscal year there would be over $7,000.00 in cash. For this reason, the committee recommends that $5,000 of the cash be invested until it is desirable to expand the operation of the fund.

MEMBERSHIP COMMITTEE

Membership in the Institute increased by 3,860, an increase of 11.3 per cent, and a slight percentage gain above last year, the largest previous individual year on record. Table II of the membership statistics shows the distribution of the membership changes among the various grades. 6,450 applications were received during the year, of which 4,168 were from Students and 2,082 from others. It is significant that the number of applications received from other than Students has shown a marked decrease.

Members in arrears for dues for the fiscal year ending April 30, 1951, amounted to 1,867, a percentage of 4.9 per cent, as compared with 4.42 per cent reported in the previous year.

Student membership has declined from 20,668 reported in 1950 to 15,028 in 1951. This is of great concern to the Membership Committee, and co-operative efforts will be continued with the Committee on Student Branches to encourage Student membership.

The increase in delinquent memberships and the decline of Student memberships can probably be attributed to the uncertainty which has confronted young engineers and Students during the past year. Recognition must be taken of this and efforts continued to reverse this trend.

Charles Clos, Vice-Chairman of the Membership Committee, participated in the study which resulted in the establishment of the Section Growth Award Plan by the Board of Directors this year.

The committee is appreciative of the efforts of the Section Membership Committees throughout the year, especially since the individuals engaged in this voluntary work have found it increasingly difficult to take time from their normal duties to devote to this activity.

COMMITTEE ON PLANNING AND CO-ORDINATION

The committee sponsored no radical departures either in planning or co-ordinating Institute activities during the past year.

Table II. Membership Statistics for Fiscal Year Ending April 30, 1951

	Honorary Members	Fellows	Members	6-Year Associates	Associates	Subtotals	Totals
Membership							
April 30, 1950	8	1,255	9,186	9,433	14,316		34,198
Additions							
New members qualified		7	235		4,785	5,027	
Former members reinstated or re-elected		3	109	64	84	260	
Subtotals		10	344	64	4,869	5,287	
Transfers		131	633	1,567		2,331	
Totals		141	977	1,631	4,869	7,618	
Deductions							
Died	1	24	86	65	29	205	
Resigned		1	61	154	169	385	
Dropped		2	89	272	474	837	
Subtotals	1	27	236	491	672	1,427	
Transfers			129	537	1,665	2,331	
Totals	1	27	365	1,028	2,337	3,758	
Net Changes	1	114	612	603	2,532	3,860	
Membership April 30, 1951	7	1,369	9,798	10,036	16,848		38,058

Table III. Number of Applications Received From Student Members and From All Others

Year Ending April 30	Students	All Others	Total
1951	4,168	2,082	6,250
1950	4,033	2,417	6,450
1949	2,286	2,192	4,478
1948	1,481	2,272	3,753
1947	938	2,331	3,269
1946	308	2,453	2,761
1945	249	2,179	2,428
1944	466	1,908	2,374
1943	783	1,431	2,214

Scheduling of Future Meetings. The future general and District meetings of the Institute have been scheduled through 1953, with some 1954 reservations already on schedule. Once again considerable attention was given to respacing the general meetings, this time with a survey of opinion among the technical advisors. The committee concluded that, with all points of view considered, the Winter General Meeting should continue to be held in general during the last week of January in New York; that, however, if the meeting be moved from New York, then consideration be given to establishing a date several weeks later in the year. The Board of Directors gave its approval.

Centennial of Engineering. The request of the American Society of Civil Engineers (ASCE) to participate in the celebration of its 100th anniversary in Chicago in 1952 was met by the appointment of a local group under the chairmanship of Frank V. Smith to arrange for national participation. The Chicago ASCE meeting will precede the AIEE Fall General Meeting in New Orleans by more than a month.

Election Procedures. At the request of President LeClair, the committee handled a brief opinion survey on the possibility of changing Institute election procedures so as to achieve greater democracy in the operation of the Institute. Of those who responded to the *Electrical Engineering* article on the subject, more than 80 per cent thought that the present system is satisfactory. No change is contemplated.

Presidential Election. At the request of the Board, the committee also investigated various methods heretofore proposed for making known the incoming president more than a year in advance with obvious advantages in committee organization, policy formation, and the like. However, no generally acceptable method was uncovered.

Constitutional Amendments. Several chores in connection with study and analysis, as well as co-ordination, were turned in on the Constitutional amendments currently before the membership.

Forum of Technical Committee Chairmen. This forum, a natural outgrowth of last year's ban on ex officio committee memberships, has held two extremely satisfactory meetings, and the third will be held in June. It provides formal location and proficient participants for discussion of the many problems that continually arise in the administration of the technical work of the Institute. The chairmanship is vested in the President of the Institute, present practice rotating the preparation of the program among the chairmen of the Committees on Publication, Standards, Technical Advisory, Technical Program, and perhaps others.

PROFESSIONAL DIVISION ADVISORY COMMITTEE

In its capacity as an advisory group for the nontechnical committees assigned to it, this committee dealt with several matters of special interest. The subject of means to be taken to broaden the effectiveness of engineers generally and to assist in the development of younger engineers in particular was considered. After a brief survey as to what action should be taken, it was concluded that the program already being formalized by the Engineers' Council for Professional Development should be supported.

Consideration also was given to the matter of consulting engineering fees in the electrical field. After reviewing this from the standpoint of policy and also the extent of membership concerned in this matter, it was agreed to leave consideration of it to organizations already constituted and having such problems in their planned field of operation.

PUBLICATION COMMITTEE

The publication policy which became effective January 1, 1947, has been carried out with minor modifications. The number of pages of published material for the calendar year 1950 is shown in Table VII together with the number of pages published in preceding years for ready comparison. The total number of pages published was 13.8 per cent greater than for the same period of the previous year, because of the increase in the number of technical papers from 202 to 238.

Electrical Engineering. One of the important ways in which a high standard of publication has been maintained is by continuing the policy of not republishing material which has been published previously elsewhere. Table VIII shows the various kinds of material in *Electrical Engineering* during the year: the Special Articles include material of broad interest, the President's messages, and the other contributions which have been submitted or solicited for publication in *Electrical Engineering* only.

Beginning with the January 1951 issue, the trim size of *Electrical Engineering* was reduced from 8³/₄ by 11⅛ inches to the standard size of 8¼ by 11¼ inches. Ultimately this will effect a saving of $10,000 annually in the cost of paper and reduced postage. The change also makes for greater uniformity on library shelves and provides increased flexibility to advertisers who furnish bleed plates.

Table IV. Number of Student Members as of April 30

Year	New Applications	Renewals	Total
1951	4,635	10,393	15,028
1950	7,876	12,792	20,668
1949	9,967	9,461	19,428
1948	7,876	6,041	13,917
1947	5,092	3,929	9,021
1946	2,574	2,513	5,087
1945	2,326	2,287	4,613
1944	2,242	2,656	4,898
1943	2,512	3,200	5,712

Table V. Record of AIEE Membership

Year	Total May 1	Year	Total May 1	Year	Total May 1
1884	71	1907	4,521	1929	18,133
1885	209	1908	5,674	1930	18,003
1886	250	1909	6,400	1931	18,334
1887	314	1910	6,681	1932	18,003
1889	333	1911	7,117	1933	17,010
1890	427	1912	7,459	1934	15,230
1891	541	1913	7,654	1935	14,269
1892	615	1914	7,876	1936	14,600
1893	673	1915	8,054	1937	15,308
1894	800	1916	8,202	1938	16,078
1895	944	1917	8,710	1939	16,605
1896	1,035	1918	9,282	1940	17,219
1897	1,073	1919	10,352	1941	17,886
1898	1,098	1920	11,345	1942	18,944
1899	1,133	1921	13,215	1943	20,161
1900	1,183	1922	14,263	1944	21,407
1901	1,260	1923	15,298	1945	23,072
1902	1,549	1924	16,455	1946	25,090
1903	2,229	1925	17,319	1947	26,470
1904	3,027	1926	18,158	1948	28,408
1905	3,460	1927	18,344	1949	30,791
1906	3,870	1928	18,265	1950	34,198
				1951	38,058

The classification of articles in *Electrical Engineering* in seven broad fields is presented in Table IX, which may be compared readily with the report of the previous year. By selecting shorter articles, more highly condensing others, and decreasing the Institute Activities section, a greater number of articles in full or nearly in full has been published. Also, the publication of digests of conference papers was discontinued beginning with the January issue. Experience had proved that digests are of little value unless the complete papers are available, and the deletion of these digests will provide 84 more pages annually for the publication of articles in full. One hundred and fifty-three articles in full or essentially in full were carried, as compared with 119 for the previous year. The number of Science and Electronics articles has increased 18 per cent, and there has been an increase in the number of Industry and General Applications papers. Papers on applications of electronic circuits and vacuum tubes cut across the five major divisions, and a separate analysis of the 153 articles indicates that 56 of the articles could be considered to have a major area of interest in the electronics field. Efforts are being made to increase further the numbers of articles in the fields of electronics, industry, and general applications.

Advertising. The number of pages of advertising during the last eight months of 1950 was about the same as for the corresponding period of the previous year. During the first four months of 1951, there was an increase of 22 pages, or 11.4 per cent more pages, than for the same period during the previous year. The general outlook for 1951 seems quite good. From contacts made during recent trips, the Advertising Director feels that this condition will continue.

Transactions. Volume 69 of the 1950 *Transactions* has been made available in two parts. Part I, which contains the papers presented during the Winter General Meeting of 1950, consisting of 670 pages, was made available for distribution in August. Part II, which contains the remainder of the papers for the year, the Board of Directors' Report, and a complete index, comprising a total of 1,082 pages, was made available for distribution on April 5, 1951.

Table VI. Deaths of AIEE Members Reported in Electrical Engineering

Name	Date of Election	Date of Death	Grade at Death	Obituary Notice in Electrical Engineering
Allen, John E.	A '21	Aug. 6, '50	F	Oct. '50, p. 936
Anderson, Burt T.	A '35	Nov. 8, '50	A	Jan. '51, p. 87
Archibald, Carl G.	A '37	Apr. 12, '50	A	June '50, p. 569
Balogh, Stephen I.	A '44	July 31, '50	A	Oct. '50, p. 936
Batcheller, Birney C.	M '17	Nov. 27, '50	M	Feb. '51, p. 170
Bennett, Edward	A '01	Jan. 10, '51	F	Apr. '51, p. 367
Boykin, Richard M.	A '13	Jan. 29, '50	M	June '50, p. 570
Brown, Frederic S.	A '12	Mar. 4, '51	F	May '51, p. 461
Brueck, Haworth L.	A '42	Apr. 11, '50	A	July '50, p. 659
Burbank, Jerome D.	A '26	Feb. 6, '51	M	May '51, p. 462
Bushnell, Robert J.	A '36	Dec. 5, '50	M	Mar. '51, p. 281
Champe, Willard C.	A '25	May 1, '50	M	July '50, p. 659
Christensen, Carlo P.	A '14	June 16, '50	A	Sept. '50, p. 848
Clark, Walter G.	A '03	Dec. 17, '50	F	Feb. '51, p. 170
Doherty, Robert E.	A '16	Oct. 19, '50	F	Dec. '50, p. 1132
Draper, Ray O.	A '45	Dec. 26, '49	A	June '50, p. 569
Eisenmenger, Hugo E.	A '11	Aug. 28, '50	M	Mar. '51, p. 281
Ellerman, Louis H.	A '28	Mar. 14, '50	M	July '50, p. 660
Fitz, Ervin M.	A '03	July 6, '50	A	Jan. '51, p. 87
Gary, Laurence A.	A '12	Aug. 23, '50	M	Nov. '50, p. 1040
Gill, Sir Frank	A '03	Oct. 25, '50	F	Mar. '51, p. 280
Hannon, Frank R.	A '20	Jan. 5, '51	A	Mar. '51, p. 281
Hare, Robert J.	M '44	Sept. 12, '50	M	Mar. '51, p. 281
Henningsen, Earle S.	A '20	Sept. 23, '50	F	Dec. '50, p. 1133
Hickok, Robert D.	M '16		F	July '50, p. 659
Hill, Stanley C. H.	A '38	Sept. 4, '50	A	Nov. '50, p. 1040
Horle, Lawrence C. F.	A '20	Oct. 28, '50	F	Jan. '51, p. 87
Hotchkiss, Frederick W.	A '20	Nov. 11, '50	M	Jan. '51, p. 87
Hubbard, Albert S.	A '95	Apr. 19, '50	A	July '50, p. 660
Jones, Frederick S.	A '14	Feb. 26, '51	M	May '51, p. 462
Kaehni, William	M '44	Jan. 27, '50	M	June '50, p. 569
Kalantar, Hamaz H.	M '42		M	June '50, p. 569
Kappeyne, Jacobus	M '16	Feb. 22, '51	M	May '51, p. 462
Kent, Walter	M '44	Feb. 10, '50	M	June '50, p. 570
Kinnaird, William R.	A '43	Oct. 19, '50	A	Mar. '51, p. 281
Knightley, William J.	A '37	Jan. 25, '51	M	Apr. '51, p. 368
Laudenslager, Richard L.	A '32	June 2, '50	M	Aug. '50, p. 736
Layman, Waldo A.	A '99	Oct. 25, '50	F	Jan. '51, p. 87
Leilich, Frank T.	A '09	Nov. 19, '50	M	Feb. '51, p. 170
Martin, Lewis G.	A '03	Apr. 1, '50	A	July '50, p. 660
Mason, Ruric C.	A '26	May 12, '50	M	July '50, p. 659
McAfee, William K.	A '16	Feb. 2, '50	M	June '50, p. 569
McBerty, Frank R.	A '01	Feb. 19, '50	F	Nov. '50, p. 1040
McCarter, Robert D.	A '99	Mar. 9, '51	M	May '51, p. 462
McClellan, William	A '04	Nov. 14, '50	F	Jan. '51, p. 87
McIver, Jr., George W.	A '08	July 24, '50	F	Nov. '50, p. 1040
Miller, Alvin A.	A '03	Apr. 5, '50	M	July '50, p. 659
Mills, John H.	A '37	Jan. 6, '51	A	Apr. '51, p. 368
Oboukhoff, Nicholas M.	M '24	July 30, '50	F	Oct. '50, p. 936
Parrack, Vasco R.	A '25	May 11, '50	F	July '50, p. 659
Parsons, John S.	A '27	Aug. 22, '50	M	Oct. '50, p. 936
Pierce, George A.	A '03	Mar. 10, '51	A	May '51, p. 461
Pike, Otis W.	A '30	Oct. 7, '50	M	Dec. '50, p. 1133
Pohnan, Frank J.	M '50	Nov. 26, '50	M	Apr. '51, p. 368
Poor, Walter E.	A '15	Apr. 4, '50	A	June '50, p. 569
Rice, Chester W.	A '13	Mar. 8, '51	F	May '51, p. 461
Rippey, Samuel H.	A '04	May 18, '50	F	Aug. '50, p. 737
Rose, Melvin C.	M '46	Apr. 23, '50	M	July '50, p. 659
Sanderford, Roger M.	A '43	Oct. 12, '50	A	Apr. '51, p. 368
Sawford, Frank	A '10	Aug. 24, '50	M	Nov. '50, p. 1040
Schauss, Stanley L.	A '43	Jan. 24, '51	M	Apr. '51, p. 368
Skinner, Charles E.	A '99	May 12, '50	F	Aug. '50, p. 736
Smith, Alzamora B.	A '40	Aug. 15, '50	A	Oct. '50, p. 936
Spinney, Louis B.	A '03	Jan. 25, '51	M	Apr. '51, p. 367
Streamer, A. Camp	A '10	May 4, '50	M	July '50, p. 658
Timmerman, Arthur H.	A '03	July 18, '50	F	Sept. '50, p. 848
Waldo, Edward H.	A '07	Aug. 30, '50	M	Nov. '50, p. 1040
Waller, James C.	A '44	Apr. 2, '50	A	July '50, p. 660
Warner, Harry O.	M '27	Sept. 16, '50	M	Nov. '50, p. 1040
Williams, John B.	A '40	Sept. 2, '50	A	Nov. '50, p. 1040
Winterroth, William C.	A '36	June 17, '50	A	Dec. '50, p. 1133
Wittig, Gustav F.	A '05	May 30, '50	A	Aug. '50, p. 736
Wolfrom, Carl A.	A '10	Aug. 3, '50	A	Feb. '51, p. 170
Woolston, Louis F.	A '20	Sept. 20, '49	F	July '50, p. 659
Wynant, James W.	A '09	May 1, '50	M	July '50, p. 658
Yensen, Trygve D.	A '09	July 2, '50	M	Aug. '50, p. 736

AIEE Proceedings. During the year, there has been a decrease in the number of *Proceedings* orders received. A total of 6,572 orders was received, representing a distribution of 54,560 copies of papers. This is an 18.4 per cent decrease in the number of order forms received and may be attributable to a smaller number of back orders for the papers of the previous year.

Divisional Publications. The committee has made an extensive study of the possibilities of issuing five divisional publications three or four times a year to take the place of the present *AIEE Proceedings*. A preliminary analysis from a sample of orders for the 1949 papers indicates that most members are ordering in a pattern the papers from three or more divisions. From a calendar of when the 1949 *Proceedings* papers were ready for distribution, it is indicated that many of the papers will be delayed two or more months if bound according to divisions. The data also show that there are not enough papers in some divisions—for example, Industry and General Applications—to issue publications quarterly. The independent survey made by a specially appointed committee, in which some 330 members were questioned, indicated that about 65 per cent of the members questioned were not in favor of incorporated sectional material in packages.

The committee felt that it did not know enough about the problem and it recommended that a survey of the membership be made to determine each member's major area of interest according to the five divisions and to determine to which other divisions each member might subscribe at a nominal annual subscription price of $2 to $3 per division.

Special Publications. During the year, the following six Special Publications have been made available and three more are in prospect. These publications are on a self-supporting basis and are made available to members at cost and in general to nonmembers at double cost through order forms published in *Electrical Engineering* from time to time.

1. Lightning Reference Bibliography, 1936–1949 (4/50)
2. Bibliography on Industrial Control (9/50)
3. AIEE Power Conference—Power Generation and Industrial Power Systems* (8/50)
4. Joint AIEE/NTF Conference on Telemetering* (8/50)
5. Electric Arc and Resistance Welding—II* (12/50)
6. Sources of Electric Energy (1/51)

* Conference Reports.

Conference Papers. There are many advantages to the presentation of conference papers; however, for some time the Publication Committee has been concerned with the increase in the number of conference papers and the decline of the formal types of papers as related to the increasing membership. Data on the matter over a 20-year period are shown in Table X. Conference papers provide an easy way of getting material which has not been reviewed on programs. The practice which permits some authors who have good facilities for the reproduction of their papers to distribute them at meetings is unfair to other authors who have good material but lack the facilities for reproduction and distribution. Presentation again by title does not provide a satisfactory solution as most of the discussion is lost, and during the interim the conference paper may have been published elsewhere. Providing conference papers in preprint form is only a partial solution, as it would not preserve the discussion and the permanent record of the paper would be lost when stock is depleted.

During the past 20 years publication costs have more than doubled. There does not seem to be any ready solution to the problem without a considerable increase in appropriations for publication purposes to provide for the increased costs and staff additions. The problem was discussed at the technical forum held during the Winter General Meeting, and it will be further explored at the forum of the Summer General Meeting.

COMMITTEE ON REGISTRATION OF ENGINEERS

The committee has continued its efforts to advise the AIEE membership on the problems of registration.

The committee held a meeting at the Winter General Meeting, which was attended by a large majority of the members.

Supplementing previously published papers sponsored by the committee, a paper by N. L. Freeman entitled "Procedures for Obtaining Registration as a Professional Engineer" was published in the February 1951 issue of *Electrical Engineering*. Reprints are available at Headquarters for use by the Sections and Student Branches and by the membership. It is planned to continue this series of papers with others, each covering some phase of registration. These are to be published in *Electrical Engineering* when

approved, and reprints of these will also be available at Headquarters.

In the 1950 issue of the Year Book, for the first time Registered Professional Engineers are indicated by a dagger. Not all who are registered are so indicated, due to the failure of some members to properly fill out their information cards. It is hoped that this will be corrected in the near future.

SECTIONS COMMITTEE

Section Activities. Two new Sections, Sacramento and Northern New Mexico, were formed.

New Subsections were formed as follows: Black Hills (Denver Section), Boise (Utah Section), Eureka (San Francisco Section), Hawaii (San Francisco Section), and Vancouver Island (Vancouver Section). Other Subsections are pending.

Section, Subsection, and membership development has been very active and healthy as noted above and as shown in Table XI.

The western portion of Louisiana, including the Shreveport Section and Lake Charles Subsection, was transferred from District 4 to District 7.

Meetings of the Sections Committee. A meeting of the Sections Committee was held during the Winter General Meeting, and a meeting is scheduled for the Section delegates during the Summer General Meeting.

Special Activities. A new revision of the "Model By-Laws for Sections and Subsections" was printed which not only brought these up-to-date, including by-laws for Subsections, but also suggested a change in the method of electing officers so as to give them a sequence of position which would result in better officer material and more experience.

At the suggestion of a special committee under the chairmanship of C. G. Veinott, a plan was approved by the Board of Directors to award four prizes to the Sections which have been the most outstanding in regard to attendance and membership growth. This will be known as the Plan for Recognition of Section Growth.

Publicity activity has been increasing in each Section, and as a further stimulation they are being offered help by Raymond C. Mayer, the Institute public relations counsel.

A thorough review has been requested of each Section regarding the necessity or advisibility of having local members, and it is hoped that some pattern for future guidance may come from this study.

A Subcommittee of the Sections Committee is studying the question of what officers of a Section should be the official representatives at its District Executive Committee meeting. At present the official delegates are the Chairman and Secretary.

General Conclusions. The figures on the rate of membership growth as well as the membership attendance at meetings are the best indications of active and effective Section operation. Present indications are for even better results in the future.

STANDARDS COMMITTEE

The Standards Committee consists of 26 appointed members and the Secretary. Two meetings have been held so far this year and a third is planned for June.

Completed Standards. Since August 1950, the following Institute Standards or Codes were completed or revised:

AIEE *52* (March 1951), Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.

AIEE *551* (August 1950), Master Test Code for Temperature Measurement.

AIEE *601* and *602* (November 1950), Large 3,600-Rpm 3-Phase 60-Cycle Condensing Steam Turbine-Generators.

AIEE *605* (September 1950), Recommended Specifications for Speed-Governing of Hydraulic Turbines Intended to Drive Electric Generators.

AIEE *807* (August 1950), Proposed Test Code for Aircraft Circuit Interrupting Devices.

Revisions of AIEE *20*, Air Circuit Breakers, AIEE *20A*, Low-Voltage Air Circuit Breakers, and AIEE *27*, Switchgear Assemblies, were completed, but approval has been withheld pending the settlement of some questions raised in the Standards Committee.

Work in Progress. It is not possible in this brief report to mention all the standardizing subjects being considered in many of the Institute technical committees. Work in progress which has been reported to the Standards Committee recently by standards co-ordinating committees, by Institute technical committees, and by subcommittees is as follows:

Standards Co-ordinating Committee Number 8, which serves as the AIEE delegation to the AIEE-Edison Electric Institute-National Electrical Manufacturers Association (NEMA) Joint Committee on Co-ordination of Insulation, has continued its study of insulation requirements and the development of basic impulse levels.

The Committee on Instruments and Measurements is preparing a Master Test Code for Power Measurements and a Master Test Code for Speed Measurements. This committee is also studying the markings of varmeters which may result in a standard.

The Committee on Electronics has formed various groups to study vacuum-tube standards. In one group progress is being made on ratings and test methods for pool tubes. Other groups are undertaking the preparation of standards on radiation detection tubes and high vacuum receiving tubes. A proposal on Symbols for X-ray Tubes was completed and submitted to the American Standards Association (ASA) sectional committee. Work on definitions in the X-ray field is also being carried on in co-operation with the ASA Sectional Committee on Definitions of Electrical Terms.

The Committee on Switchgear is considering the preparation of standards for network protectors.

The Committee on Transformers has under preparation certain proposed revisions in the American Standard for Transformers.

Active work is in progress in revising certain of the test codes which are under the jurisdiction of the Committee on Rotating Machinery. These are being co-ordinated with the American Standards for Rotating Machines as they are, in effect, made a part of these standards by references in the latter. This technical committee is also preparing recommendations for the consideration of the ASA sectional committee which is at present engaged in making a revision of the American Standards.

The Standards Subcommittee of the Committee on Industrial Control has been studying possible changes which might be proposed in the American Standard drawing symbols.

A subcommittee of the Standards Committee is correlating standard temperature rises at the terminals of apparatus.

Work With Other Organizations. An Institute Subcommittee on Standard Frequency Bands and Designations has developed a proposed standard which designates each frequency band by a number which is the logarithm of the lowest frequency in the band. This subcommittee has co-operated with an Institute of Radio Engineers (IRE) committee to arrive at this proposed standard, which has been submitted to the Department of State as a joint AIEE-IRE recommendation for the purpose of having it included on the agenda of the

Table VII. Numbers of Pages of Published Material

Year	Electrical Engineering: Technical Articles	Electrical Engineering: News	Electrical Engineering: Transactions Sections	Transactions Only: Technical Papers	Transactions Only: Discussions	Transactions Only: Total
1941	337	281	600	542	268	2,028
1944	246	214	738	493	231	1,922
1945	255	225	736	121	143	1,480
1946	285	315	832	254	120	1,806
1947	806	474		1,600*	153*	3,033
1948	832	395		1,643†	172†	3,042
1949	796	320		1,275‡	167‡	2,558
1950	836	323		1,579**	173**	2,911

* Preprinted 227 papers as *AIEE Proceedings*, except for a 17-page technical paper in *Electrical Engineering*.

† Preprinted 247 papers as *AIEE Proceedings*, requiring a total of 2,090 pages.

‡ Preprinted 202 papers as *AIEE Proceedings*, requiring a total of 1,795 pages.

** Preprinted 238 papers as *AIEE Proceedings*, requiring a total of 2,014 pages.

Table VIII. Material in Electrical Engineering, May 1950 to April 1951

	Number of Articles	Number of Pages	Per Cent Pages
Special Articles	60	216	17.9
Technical Papers	58*	291	24.1
Conference Papers	35**	147	12.2
One-Page Digests	120	120	10.0
Conference Paper Digests		23	1.9
Essays		29	2.4
Filler Items	25	10	0.8
Institute Activities Section		211	17.5
Current Interest Section		85	7.0
Industrial Notes, Trade Literature, and so forth		27	2.2
Title and Highlights Pages	24	24	2.0
1950 Index	1	24	2.0
		1,207	100.0

* 34 of these were condensed.

** 9 of these were condensed.

Table IX. Classification of Articles in Electrical Engineering in Seven Broad Fields

(Exclusive of 1-Page Digests)

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	Total
General interest	4	1	3	3	1	2	2	4	2	4	5		31
Educational	1	1						1	1			1	5
Science and electronics	3	3	4	2	6.5	4.5	4	3	1	2	2	3	38
Communication	1	1		1	1		2	1	1	1	3	2	14
Power	3	4	3	2	2.5	3.5	5	2	4	5	4	2	42
Industry	1	2	1	2	1	2		2			1	2	14
General applications	1		1			2	1	1	1			2	9
Totals	16	12	12	10	12	14	14	14	10	12	15	12	153

meeting of the International Consultative Committee on Radiotelephony (CCIR) to be held in Geneva in June, with a view to adoption as an international statement.

Institute representatives serve on a number of committees of other organizations and on some joint committees of other organizations. During the year, a Joint AIEE-IRE Committee was formed to deal with new definitions relating to noise which are coming into use, and an AIEE subcommittee is working with an IRE subcommittee on the preparation of definitions for telemetering.

American Standards Association. The Institute has continued support of the ASA by participation in the work of the ASA Standards Council, the ASA Electrical Standards Committee, the ASA Drawings and Symbols Correlating Committee, and the Mining Standardization Correlating Committee through its representatives on these committees. The Institute is sole sponsor for eight ASA projects, most of which are under sectional committee procedure. A number of these have been active during the year as follows:

The AIEE Committee on Land Transportation has completed a proposed revision of the American Standards for Electric Control Apparatus for Land Transportation Vehicles, ASA *C48*, AIEE *16*, which will be published for trial use. AIEE is proprietary sponsor of this project.

Progress is being made in the tremendous task of revising the Definitions for Electrical Terms, ASA *C42*.

A Sectional Committee on Capacitors has been organized which will consider revision of American Standard *C55*, AIEE *18*, Standards for Capacitors. A proposed revision has been prepared by the Capacitor Subcommittee of the Committee on Transmission and Distribution.

A subcommittee of the Committee on Instruments and Measurements, which also serves as ASA Sectional Committee *C68*, reported that it has prepared a proposed revision of the American Standard for Measurement of Test Voltage in Dielectric Tests, ASA *C68.1*, AIEE *4*.

Upon invitation of ASA, the Institute has recently undertaken to serve as sole sponsor of the project on Electrical Equipment in Metal Mines, *M24*. The sectional committee is being reorganized, and interested organizations are being canvassed to obtain the names of their representatives.

The Institute serves as joint sponsor with the National Fire Protection Association on ASA Project *C5*. This project relates to the Code for Protection against Lightning, a revision of which has been completed and is in the process of approval as an American Standard.

Other ASA projects on which the Institute serves as joint sponsor are *C19*, Industrial Control Apparatus, with NEMA; and *Z32*, Graphical Symbols and Abbreviations for Use on Drawings, *Z32*, with American Society of Mechanical Engineers. The organization and personnel of both of these sectional committees is at present being reviewed in prospect of renewed activity in these subjects.

The Institute is represented on 56 other ASA sectional committees, but no attempt is made in this report to cover the very considerable contributions which AIEE representatives have made to these ASA projects for which the AIEE does not have the responsibility of sponsorship.

Standards Committee Organization. It became apparent that there is a need for some guidance to Institute committees which develop standards in the voting procedure in these committees and in reporting the degree of consensus obtained on standards which they pass to the Standards Committee for approval. The Standards Committee has appointed a subcommittee to study and report on this subject.

The Standards Committee regards its close working relations with the Institute technical committees and its representatives on other committees as highly important. During the year one of the subjects of chief concern was to bring about some form of liaison with these committees comparable to the former relations obtained by ex officio memberships on the Standards Committee.

UNITED STATES NATIONAL COMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION

Dr. H. S. Osborne, Chief Engineer of the American Telephone and Telegraph Company, was re-elected President of the United States National Committee (USNC) of the International Electrotechnical Commission for the calendar year of 1951. At the same time, P. H. Chase, Chief Engineer of the Philadelphia Electric Company, and R. C. Sogge, Manager of the Standards Division of the General Electric Company, were elected as Vice-Presidents of the USNC for the calendar year of 1951.

At the invitation of the French Electrotechnical Committee, the International Electrotechnical Commission (IEC) held its annual meeting in Paris from July 10 to 21, 1950. This meeting was attended by almost 300 delegates representing 16 nations, and was the largest meeting of the IEC since the war. It comprised meetings of 11 international technical committees, several subcommittees, and the International Special Committee on Radio Interference (CISPR). The IEC Committee of Action, which deals with administrative matters in the interval between meetings of the Council, also met. The United States was represented by 14 technical delegates well versed in their respective fields. The delegation was headed by P. H. Chase, Vice-President of the USNC. Meetings of the following technical committees were held in Paris:

Technical Committee 3—Graphical Symbols
Technical Committee 7—Aluminum
Technical Committee 12—Radio Communication
Technical Committee 23—Electrical Accessories
Technical Committee 24—Electric and Magnetic Magnitudes and Units
Technical Committee 25—Letter Symbols
Technical Committee 28—Co-ordination of Insulation
Technical Committee 32—Fuses
Technical Committee 33—Power Capacitors
Technical Committee 34—Lamps, Lamp Caps, and Holders
Technical Committee 35—Dry Cell Batteries

In addition, a meeting of Technical Committee 5 on Steam Turbines was held in London July 6 to 8, 1950.

Considerable progress has been made in the technical committees during the year. Several proposed international recommendations in the field of radio, electric lamps, letter symbols, turbine-type generators, and electric motors are now before the national committees of the member countries of the IEC for approval as International Standards. Among these are:

Color Code for Fixed Resistors

Specification for Series of Preferred Values and Their Associated Tolerances for Resistors and Capacitors for Apparatus for Radio-Communication

Specification for Tungsten Filament Lamps for General Service

International Letter Symbols for Use in Connection with Electricity—Magnitude Symbols, Alphabets, and Letter Type

Table X. Growth of Conference Papers and Decline of Published Papers in Proportion to Membership Over a 20-Year Period

	Calendar Years				
	1930	1935	1940	1944	1950
Number of Conference Papers		64*	58*	88*	284
Number of District Papers		8	12	21	105
Number of ACO Papers	32	3	8	8	44
Total of Unpublished Papers	32	75	78	117	433
Number of Transactions Papers	167	127	155	231	238
Membership as of May 1st	18,003	14,269	17,213	21,407	34,198
Unpublished Papers × 100/Membership	0.178	0.526	0.453	0.546	1.27
Published Papers × 100/Membership	0.93	0.89	0.90	1.08	0.696

* 50 per cent estimated (assumption 4 papers per conference).

Preferred Standard 3,000 Rpm 3-Phase 50-Cycle Turbine Type Generators

Two new subcommittees have been organized: one on Dimensional Standards for Electric Motors, and another on Turbine-Type Generators. Meetings of these groups were held in London in November 1950, and a representative of the USNC was present at both meetings.

During the course of the year, two new member countries have been added to the IEC; namely, Israel and Yugoslavia.

The next annual meeting of the IEC will be held in Estoril, Portugal, during the period of July 4 to 12, 1951. In addition to meetings of the Council and Committee of Action, meetings of the following technical committees have been scheduled to be held at that time:

Technical Committee 1—Nomenclature
Technical Committee 2—Rotating Machinery
Subcommittee 2A of Technical Committee 2—Turbine-Type Generators
Subcommittee 2B of Technical Committee 2—Dimensions for Electric Motors
Technical Committee 8—Standard Voltages and Currents
Subcommittee 3 of Technical Committee 12 on Radio Components
Technical Committee 14—Transformers
Technical Committee 15—Insulating Materials
Technical Committee 17—Switchgear
Technical Committee 28—Co-ordination of Insulation

Arrangements have been made for the USNC to be well represented at these meetings.

The invitation extended by the USNC to hold meetings in the United States in 1954 to celebrate the 50th Anniversary of the founding of the IEC (which was founded in St. Louis, Mo., in 1904) has been accepted, and preliminary plans are now being made for these meetings.

UNITED STATES NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION OF ILLUMINATION

During the year 1949–1950, the United States National Committee has been actively engaged in preparation for the sessions which are to be held in Stockholm in June 1951. An organization meeting for the Stockholm sessions was held in Amsterdam on January 23. At this meeting, the recommendations of the USNC for separate sessions for papers of general interest received favorable consideration. Five of the six papers submitted by Americans have been accepted for presentation. These are:

The Engineering Evolution of the Fluorescent Lamp by Dr. E. F. Lowry, Sylvania Electric Products, Inc.

The Subjective Appraisal of Brightness by S. K. Guth, General Electric Company

Daylight in Classrooms by Prof. R. L. Biesele, Jr., Southern Methodist University

Home Lighting Practice by Miss Myrtle Fahsbender, Westinghouse Lamp Division

Space Concepts of Lighting by R. G. Slauer, Sylvania Electric Products, Inc.

In addition, the USNC has been requested to invite Doctor Evans of the Eastman Kodak Company to present a paper on color and vision at a special meeting. Present indications are that the USNC will be represented at the Stockholm sessions by an exceptionally large and well-qualified delegation, with at least one outstanding United States expert at every committee meeting.

During the year, it developed that the Central Bureau, which is now located in the United States, lacked both manpower and financial resources to carry on the work. Unusual expenses in connection with the production of the Proceedings and the devaluation of the pound had reduced the available income to an amount far below that necessary for the successful operation of the Bureau. If the International Commission of Illumination is to continue to exist and grow, some arrangements must be made to ensure more adequate and reliable sources of income. The present annual dues from national committees ($6,000) will not support this activity.

Therefore, it was proposed that a committee be constituted to raise funds to assist in financing the Central Bureau from June 1, 1950, to June 1, 1952, these funds to be solicited from firms engaged in the lighting business on an international scale. This proposal was placed before the members of the USNC in the form of a letter ballot and was approved. One of the first activities of this committee was the preparation of an informational brochure. It was originally planned to ask United States firms to underwrite the operation of the Central Bureau in the amount of $24,300, for the period June 1, 1950, to June 1, 1952, only, but it now appears that $30,000 will be needed. A report on the outcome of these solicitations has not been made yet. A system of sustaining membership on an international basis similar to the procedure in use in the Illuminating Engineering Society is also under consideration.

COMMITTEE ON STUDENT BRANCHES

Upon the recommendation of the Committee on Student Branches, the Board of Directors authorized the establishment of four additional Student Branches during the year. These Branches were authorized at the University of Massachusetts, the University of Toledo, and the United States Naval Academy. These additional Branches bring the total number to 133.

Sections 33, 51, 53, 60, and 84 of the By-Laws, relating to Student membership and Student Branches, were amended by the Board of Directors at its meeting on October 26, 1950, in accordance with the recommendations of the Committee on Student Branches and the Committee on Constitution and By-Laws. These changes in the By-Laws clarify certain points regarding Student membership, include the Chairmen of the District Committees on Student Activities as appointed members of the Committee on Student Branches, and adjust the times for nominating and appointing District Committees on Student Activities. The latter adjustments enable the President-elect to appoint the members of the Committee on Student Branches at the same time other committee appointments are made.

A previous amendment of Section 53 of the By-Laws changed the Student membership dues from $3.00 to $5.00 per year. The increase will become effective May 1, 1951. This is the first change in the Student membership dues since that grade of membership was established in 1903. When the dues were increased, the Board of Directors requested the Committee on Student Branches to investigate and report to the Board ways and means by which the Institute may further promote the student program. A subcommittee charged with the responsibility of this investigation has been working on the project since the summer of 1950 and submitted a progress report at the January 23, 1951, committee meeting. The progress report was reviewed and referred back to the subcommittee for further investigation and a report at the June meeting of the committee in Toronto, Canada.

Last year, a subcommittee presented a report on making available to each of the Branches a certificate to be awarded, at their discretion, to a Student member for outstanding activity. After further study, this report was recommended to the Board of Directors and it was approved by the Board at its meeting on January 25, 1951. These certificates were made available to the Branches this year.

The Joint AIEE-IRE Co-ordination Committee at its meeting on November 7, 1950, made the following recommendation to the AIEE and IRE:

"That a continuing joint subcommittee be established under the Education Committee of the IRE and the Student Branch Committee of the AIEE. The purpose of the subcommittee will be to resolve differences of Joint Student Branches, which are of such magnitude or of such specialized nature that they cannot be settled by the Executive Secretary of the IRE and the Secretary of the AIEE."

The Committee on Student Branches recommended such a joint subcommittee to the Board of Directors, and it was approved by the Board at its meeting on January 25, 1951. The Board of Directors of the IRE had previously approved the joint subcommittee on November 8, 1950, and it has been established.

Because of the number of Student members being called into the armed services, the committee recommended to the Board of Directors that the policy of granting suspended membership for Student members, followed during World War II, be applied in the present national emergency. This recommendation was approved by the Board, to become effective at the beginning of the fiscal year, May 1, 1951.

Table XI. Section and Branch Statistics

	For Fiscal Year Ending April 30					
	1946	1947	1948	1949	1950	1951
Sections						
Number of Sections	75	75	81	84	87	89
Number of meetings held	1,210	1,333	1,340	1,561	1,605	1,716
Total attendance	113,531	155,649	109,637	128,025	135,847	125,779
Branches						
Number of Branches	125	126	127	129	130	132
Number of meetings held	716	1,018	1,172	1,350	1,298	1,281
Total attendance	22,844	40,669	77,040	103,828	80,672	62,630

The committee held two meetings, one in Pasadena, Calif., on June 14, 1950, and the other in New York, N. Y., on January 23, 1951.

TECHNICAL ADVISORY COMMITTEE

Technical Committee Organization. Two new technical committees were established in the Science and Electronics Division to meet the expanding activities of this division. The Subcommittee on Magnetic Amplifiers was transferred to technical committee status, and the Committee on Therapeutics was merged with the Joint Subcommittee on Electrical Aids to Medicine to form the new Committee on Electrical Techniques in Medicine and Biology, thereby increasing the number of active technical committees to a total of 39.

Administration of Joint Subcommittees. Progress was made during the year toward reducing the number of joint subcommittees subject to joint administration. The Joint Subcommittee on Electrical Aids to Medicine was merged into the Committee on Electrical Techniques in Medicine and Biology, as noted above, and the Joint Subcommittee on Instrument Transformers was assigned for administrative purposes to the Committee on Transformers. Joint administration of a limited number of joint subcommittees will continue into the next administrative year, partly to afford additional experience, and partly in anticipation that some subcommittees will be transferred to the status of technical committees.

Special Technical Conferences. Special technical conferences have become a permanent Institute technical activity. On an over-all basis, this activity has been financially self-sustaining.

Member Classification. The lack of a classification of Institute membership according to interest has been a drawback in the preparation of mailing lists to publicize special technical conferences and other technical activities. Various means for establishing a classification are under study. Consideration is being given to the utilization of the tabs on the available addressograph equipment to permit classification according to Division interest as the first step toward a more complete classification.

AIEE Participation in Centennial of Engineering. The Technical Advisory Committee is co-operating with the local committee for the participation of the Institute in the centennial anniversary celebration of the American Society of Civil Engineers scheduled for the week of September 7, 1952, in Chicago. Preliminary plans provide for three days of AIEE-sponsored sessions on subjects appropriate to the occasion. Liaison is being effected by representation from each Division on the local committee.

Committee Scopes. Efforts were continued during the year to bring existing technical committee scopes up to date and to have scopes prepared for subcommittees and working committees where these were lacking. A complete roster of personnel and scopes for these subcommittees has been included in the Year Book for 1950.

Technical Activities. The technical activities of the Institute continued at an increased rate during the year as indicated elsewhere in the annual report. The problem of equal distribution of the burden of technical sessions among the four general meetings of the Institute has been considered. Studies toward effecting a satisfactory solution will be continued.

Technical Conference Papers. The status of technical conference papers has been reviewed, with indications of the need of remedial action. It has become quite apparent that conference papers are no longer being used as originally intended. Instead, they have grown in number to such an extent that they constitute the major form of paper presentation. The effect has been a loss in the *Transactions*, which constitute the permanent record of the advancement in the art of electrical engineering, of some valuable material. Much of the difficulty stems from the fact that the budget does not permit publications to parallel the expansion of the technical activities of the Institute.

Manual of Instructions. The manual of instructions made available to technical committee chairmen, as a source of information for their guidance in the performance of their duties, has been revised and enlarged in light of the experience during the past year. A calendar of dates covering general and District meetings, closing dates for paper submission, and so forth, has been included for the convenience of chairmen.

Forum of Technical Committee Chairmen. Forum meetings of technical committee chairmen with a panel of appropriate general committee chairmen were instituted at the Fall General Meeting. Although originally contemplated as an annual event, the Oklahoma City forum meeting was so successful that it was followed by a meeting in New York City, and a third is to be held in Toronto. The objectives of the forum are to afford an opportunity for the exchange of opinions, the submission of expressions for preferred action on matters relating to technical activities, and the statement by chairmen of general committees of specific problems and the extent of co-operation desired from technical committee chairmen.

The New York City forum is responsible for the recent Board action permitting the waiver of registration fees for nonmember authors who have been invited to present papers before the Institute members.

TECHNICAL PROGRAM COMMITTEE

Papers Presented. Technical activity in the Institute continues to rise, and the past year sets a new record in papers presented and published. This increased activity was especially noticeable at the Winter General Meeting, where there were eight concurrent sessions at many periods on the program, and a total of 68 technical sessions and conferences were held. The two sessions on "Operation of Utilities under Military Attack" were of outstanding interest. A tabulation of papers classified by meetings is given in Table XII.

Conference Papers. A record number of papers has been accepted for *Transactions*, but the increase in conference papers continues to be the outstanding trend. This channel for bringing recent developments promptly to the attention of our membership has been especially important in the Communication and Science and Electronics Divisions. The conference papers presented appear to be appropriate for this channel because only about 10 per cent of them are subsequently presented by title and published in *Transactions*. It should be recognized that much of the material presented in conference papers cannot be made available in any more formal manner.

Relation of Forum and Technical Program Committee. The forum of technical committee chairmen, which held the first meeting in Oklahoma City, provides a valuable opportunity to discuss Institute problems. The discussion of registration fees for nonmember authors at the Winter forum brought the problem to the attention of the Directors who took appropriate action. Conference papers were also considered at the Winter meeting, and will be continued on the agenda at the Summer meeting. The needs of the Technical Program Committee would be served more effectively if this committee held a special forum during September. This meeting should discuss details of handling technical papers, particularly for the information of new committee chairmen. Tentative plans for the technical program for the year could also be made. A forum at the Fall General Meeting comes a little late for best results and may not be well attended by technical committee chairmen.

COMMITTEE ON TRANSFERS

In addition to answering quite a number of communications from Section transfer committees, the committee held two general meetings—one in Pasadena, in June, and the second in New York, in January. At the Pasadena meeting, Lloyd Hunt of the Los Angeles Section described an activity which appeared to have considerable merit. They have formed the Fellows of that area into a group called the Royal W. Sorenson Fellows, having one meeting per year. This meeting provides an opportunity for the Fellows in the Los Angeles area to get together informally and at the same time gives a certain amount of recognition to that group.

At the New York meeting of the committee, it was decided to withhold printing

Table XII. Numbers of Papers Presented During the Year Ending April 30, 1951

Meeting	District	Advance Copy Only	Conference Papers	Transactions	Total	Attendance
Great Lakes District Meeting	21	2		3	25	536
Summer and Pacific General Meeting	13		85	53	151	1,665
Middle Eastern District Meeting	68	3		24	95	972
Fall General Meeting	12		59	51	122	1,144
Winter General Meeting	24	161		119	304	3,334
Southern District Meeting	27	2		5	34	328
Total	116	56	305	255	731	7,979

of the guide for local transfers committees until the proposed changes in membership requirements and the procedure in the election of Fellows had been voted upon by the membership. The committee urges that, as soon as the new requirements and procedures are decided and settled, this guide be revised and issued, as there is a definite need for it.

TECHNICAL DIVISIONS AND COMMITTEES

Communication Division

COMMITTEE ON COMMUNICATION SWITCHING SYSTEMS

One committee meeting was held and two technical sessions were sponsored. The session on the subject of community dial offices referred to in last year's report was held at the Fall General Meeting. There appeared to be considerable general interest in this subject, and the committee is attempting to obtain sufficient papers on it to constitute a second session for the Fall General Meeting. The session sponsored for the Winter General Meeting covered subjects on telegraph switching and supervisory arrangements developed for long-haul telephone trunks. This session was well attended and the discussions were lively and stimulating.

The committee expects to be able to sponsor a symposium of papers on the subject of nation-wide operator toll dialing at the 1952 Winter General Meeting. In view of the wide interest in this subject and its extreme importance in the telephone switching field, it should constitute a meeting of considerable interest.

COMMITTEE ON RADIO COMMUNICATIONS SYSTEMS

The committee held one formal meeting—on January 25, 1951. Mr. Dickieson, Chairman of the Subcommittee on Mobile Radio, submitted a comprehensive report of the work done on the protection of fixed radio stations, intended for mobile radio service, against damage by lightning. This report is now being studied and revised in preparation for publication.

The committee sponsored one session at the Winter General Meeting and one session at the Summer General Meeting, and suggested papers for presentation at the Pacific General Meeting.

COMMITTEE ON SPECIAL COMMUNICATIONS APPLICATIONS

This committee has served to handle subjects that do not logically fall within the scope of other committees in the Communication Division. Activities concerned with recording, public address systems, printer circuits, and various components have been handled during the past year. The committee has processed several papers covering these topics, which cover a wide range of interest.

COMMITTEE ON TELEGRAPH SYSTEMS

The past year's work of this committee culminated during the Winter General Meeting in a well-rounded technical session covering several recent developments in electronic applications to telegraphic communication. A meeting of the committee also was held during the Winter General Meeting to review the progress of the year and set a course for the coming year. It was obvious that considerable interest had been aroused by the several papers presented on multiplex operation, particularly on the subject of the relative merits of frequency versus time-division systems. The committee therefore concluded that it would be worth while to pursue the subject further. It is hoped that this will result in an additional paper on a new time-division system and a paper on recent applications of frequency-shift diplexing, possibly for the Fall General Meeting.

It was agreed that active work should proceed on a collection of reference information on the various types of printers, codes, keyboards, and so forth, used in the operations of American and foreign telegraph carriers. The need for such a collection was recognized in the previous year, but, because of the pressure of other matters, the work of preparation had to be postponed.

Several new developments were brought to the attention of the committee. Short-haul carrier facilities have been developed to alleviate the shortage of d-c physical wires for telephone service, and may provide an interesting paper during the coming year. New terminal equipment is being developed for the rapid setting-up and changing of program networks. Modern traffic engineering aspects of the terminal handling of record communications by printer, facsimile, telephone, and messenger warrant further attention by the committee.

The growing importance of facsimile in both military and civilian applications should be of interest. New continuous recorders, high-speed techniques for transmission of printed matter as well as photographs and drawings, and the application of such equipment to practical telegraph systems, indicate that there may well be material for a future technical session on facsimile. All of these items are being followed closely by the committee.

COMMITTEE ON TELEVISION AND AURAL BROADCASTING SYSTEMS

This committee was newly formed this year, combining the scope of the former two Committees on Television Systems and Aural Broadcasting Systems. One meeting of the committee was held on September 15, 1950, at which plans were made for sponsoring technical sessions. During the Winter General Meeting the committee sponsored a technical session on the more recent developments in the television field. Three papers on color television and one on ultra-high-frequency television were presented and were well received by the large group in attendance. Work is in progress toward sponsoring a session on broadcasting at the Fall General Meeting. A review was prepared, which was subsequently published in *Electrical Engineering*, covering the outstanding developments during 1950 in the field of broadcasting. Since it was thought that standardizing work was being adequately covered by other groups, no new work in this direction was undertaken this year.

COMMITTEE ON WIRE COMMUNICATIONS SYSTEMS

This committee held meetings and sponsored technical sessions at the Summer and Pacific, Fall, and the Winter General Meetings, and plans meetings at the Summer and Pacific General Meetings. These meetings have enabled more members to attend committee sessions than was possible when only New York committee meetings were held. Consideration is being given to establishing standards of various types, and information is being gathered toward that end. While the need for such standards is clear, it is not yet certain that they can be successfully prepared in the present state of the art.

General Applications Division

COMMITTEE ON AIR TRANSPORTATION

The committee met last October at the Middle Eastern District Meeting. Tentative plans were made for the 1951 meeting to be held in Portland, Oregon, in conjunction with the Pacific General Meeting. Since then, the greatly increased activity in the aircraft industry has made it imperative to hold the meeting near the largest possible concentration of aircraft activity. The committee plans to have a special technical conference on aircraft equipment in Los Angeles, Calif., October 8–10.

Aircraft Electrical Rotating Machinery Subcommittee. On March 16, 1951, copies of a Proposed Test Code for D-C Machines was mailed to the members of the Committee on Air Transportation and other interested parties. The subcommittee is presently working with the Systems Subcommittee in the review of the "Aircraft Electric System Guide Report, AIEE *750*."

Principles of Altitude Rating of Electrical Apparatus Subcommittee. A report titled "Generator Blast-Air Cooling" has been compiled, and is now in the process of circulation among the members of the subcommittee for comments. When the comments are received, it will be revised and submitted to the main committee.

Information is being compiled on variation of air temperature with altitude so that a series of curves may be drawn giving realistic temperature limits for use in designing electric apparatus for aircraft.

Aircraft Electrical Systems Subcommittee also is reviewing the "Aircraft Electric System Guide Report, AIEE *750*." It is expected that revised drafts of certain sections of this report and certain new sections will be prepared for consideration by the Committee on Air Transportation.

Aircraft Electrical Control, Protective Devices, and Cable Subcommittee is reviewing the AIEE Preliminary Test Code *801* on circuit breakers for the purpose of co-ordination with the new MIL-G-Specification.

The proposed AIEE Test Code on Aircraft Carbon-Pile Voltage Regulators is being reviewed in light of the comments received following circulation to members of the Committee on Air Transportation.

Sections 400 and 500 of the Aircraft Electric Systems Guide, AIEE Report *750*, are being reviewed.

COMMITTEE ON DOMESTIC AND COMMERCIAL APPLICATIONS

The activities of the committee are carried on by four subcommittees, three of which

have been functioning in the past, while one is new.

Subcommittee on Electric Space Heating and Heat Pumps for the Pacific Coast is co-operating with the program committee for the Pacific General Meeting. The subject is timely, especially for that section of the United States, and because of the relative newness of the application there is much opportunity for the exchange of technical information tending to foster engineering progress in this field.

Subcommittee on Electric Space Heating and Heat Pumps for the East sponsored a very successful session at the Winter General Meeting. This followed a similar session a year ago, and the large attendance at both sessions gave evidence of the interest which this subject holds in the East, as well as on the Pacific Coast.

Subcommittee on Domestic Appliances is co-operating with the Columbus Section for a technical conference to be held at Battelle Memorial Institute in Columbus, Ohio, on May 15. A technical conference sponsored by this same subcommittee in June 1950 in Cleveland, Ohio, was well attended. The two subjects were automatic washers and electric ranges. That conference probably was the first AIEE meeting ever devoted solely to the subject of domestic appliances. A considerable segment of the appliance industry does not have adequate outlet for the exchange of technical information, and it is the hope of this committee that this industry will use AIEE as a forum for engineering advances in this important field.

A new Subcommittee on Farm Electrification was formed during the year which has not been active as yet, but the groundwork has been laid for continuance in future years of activity in this field. While AIEE has taken an active part in meetings and papers relating to the problems of bringing electric power to the farm, there has been comparatively little attention paid, technically, to the many and rapidly growing applications for the utilization of electricity in farming. The committee has had a delegate to the National Farm Electrification Conference, L. R. Emmert, who is also chairman of this subcommittee. Future subcommittee activity in this field will include co-operation with other organizations, including the American Society of Agricultural Engineers.

COMMITTEE ON LAND TRANSPORTATION

This committee has been very active during the year in keeping the Institute informed, by papers and reports, of the progress and new developments in land transportation. It participated in the programs of the Summer and Pacific and Winter General Meetings. The papers sponsored and presented by this committee at these two general meetings covered an unusually broad scope. At Pasadena, the papers presented were specifically related to the design features of the electric and Diesel-electric locomotives, by means of which the American railroads are becoming "electrified" rapidly.

The papers presented during the first session of the Winter General Meeting were devoted to heavy traction subjects, which covered the recent improvements in multiple-unit car motors, both a-c and d-c, and their control, a description of a new train performance calculator, and the technical details of the modern cab signaling and train control equipment now in use on many railroads. The second session was devoted to light traction subjects, the papers covering recent progress in design of light-weight rapid transit cars, their motors and control, and the power supply problems of urban trolley-coach operation. All meetings were unusually well attended, and, in the discussion of the papers, the members present indicated by their keen interest that progress is still being made in electric transportation which is now over 55 years old.

In September 1950 a large group of European railway engineers and officials were brought to this country under the auspices of the Economic Co-operation Administration. Many of the members of the committee had the opportunity of meeting with the subgroup studying American railway electrification, and are now keeping in close touch with recent electric transportation developments in Europe.

In addition to sponsoring the presentation of papers, two meetings of the committee were held, the first in Philadelphia in May, where members had the opportunity of inspecting the "Ignitron-rectifier" car with d-c motors in use on the Pennsylvania Railway a-c electrification and the electric train performance calculator which had recently been placed in service on that railroad. New a-c multiple-unit car equipment recently acquired by the Reading Railroad was inspected also. The second meeting of the committee was held during the Winter General Meeting, at which time plans for participation in the Summer General Meeting were outlined. A well-organized program of papers for presentation in two sessions has been prepared.

COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT

A lively conference session under the auspices of this committee was held during the Winter General Meeting, where there was an open discussion of the problem of the measurement and control of audible noise from fluorescent lighting equipment.

At the annual committee meeting, held during the Winter General Meeting, plans were laid for an added session next year, probably in connection with the Fall General Meeting, to deal with problems of lighting as affected by the critical materials situation. It is probable that this session will be co-sponsored by the Subcommittees on Distribution Systems for Industrial Plants and Distribution Systems for Commercial Buildings of the Committee on Industrial Power Systems.

The subject chosen for the usual session at the next Winter General Meeting is "Ultraviolet Radiations." The Subcommittee on Ultraviolet Radiations will make a formal report at that time.

COMMITTEE ON MARINE TRANSPORTATION

The committee held two well-attended meetings at Institute headquarters, in May and December. It has been working on revisions to "Recommended Practices for Electrical Installation on Shipboard," as issued in December 1948. As the stock of this Standard was exhausted, the committee requested the Institute to reprint the 1948 issue with a supplementary sheet covering corrections for use until such time as the 1948 issue could be revised. It also has been working on the international standardization of electric installations on shipboard.

Subcommittee Activities. Subcommittees consist of: Power Generation, Power Applications, Wires and Cables, Switchboards and Controls, Distribution, Fittings and Appliances, Communications and Alarms, and Navigation Equipment. All of these subcommittees have been quite active, each reviewing the sections of Standard 45 under its cognizance and making reports to the main committee for action.

Industry Division

COMMITTEE ON CHEMICAL, ELECTROCHEMICAL, AND ELECTROTHERMAL APPLICATIONS

The committee held a meeting at the Winter General Meeting, at which it was decided to recommend a shorter committee name. The name of the Arc Furnaces and Electrothermal Processes Subcommittee was changed to the Electrothermal Processes Subcommittee. The name of the Petroleum Refining and Production Subcommittee was changed to the Petroleum Industries Subcommittee.

Sessions were held in Pasadena in conjunction with the Committee on Industrial Power Systems, in Oklahoma City, two at the Winter General Meeting, and one at the Southern District Meeting.

For the coming year, this committee is sponsoring a session each for the Summer, the Pacific, and the Fall General Meetings, and three sessions for the Winter General Meeting.

Electrothermal Processes Subcommittee is continuing its study of the problems of arc furnace application, and is planning a full session with emphasis on operating conditions.

Cathodic Protection Subcommittee held a meeting in Oklahoma City and one at the Winter General Meeting, and has scheduled a meeting for the Fall General Meeting. A 5-year schedule of activities has been worked out, and the subcommittee will coordinate its work with that of the National Association of Corrosion Engineers. A full session is scheduled for the Fall General Meeting.

Electrolytic Processes Subcommittee has a full session planned for the Pacific General Meeting on "Electrical Applications in the Aluminum Industry."

Petroleum Industry Subcommittee prepared a full session on "The Petroleum Industry in Canada" for the Summer General Meeting, and is planning two sessions for the Winter General Meeting on "Electrical Applications for Pipe Line Transportation."

Storage Batteries Subcommittee is working on the basic problem of defining storage battery capacity, and is collecting information on various types of accumulators which will appear in one or more papers.

Chemical Industry Subcommittee is planning a full session for the Winter General Meeting, and will present a summary of the properties of cable insulations suitable for chemical plants and refineries.

COMMITTEE ON ELECTRIC HEATING

The committee did not sponsor any sessions at general meetings since it was considering a possible special conference. This was finally postponed for the present because of various difficulties which arose. Instead, sessions are being considered for the Fall and Winter General Meetings.

Induction and Dielectric Heating Subcommittee has completed its work on proposed definitions, and is endeavoring to secure approval. Final assembly of proposed equipment standards is going on at present. A continuing function is cooperation with the Federal Communications Commission on reports of radio interference from heating equipment.

Radiation Measurements Above 300 Megacycles Subcommittee has almost completed its work on Recommended Practice for Measurement of Field Intensities above 300 Megacycles from R. F. Industrial, Scientific and Medical Equipments. It is expected that this will shortly be presented to the Standards Committee for approval.

Radiant Heating Subcommittee is continuing its investigation into basic information over a wide field, covering selective absorption of different wavelengths by various materials, characteristics of different heat sources, and new applications.

Technical Data Subcommittee is a new group organized to gather into working form information on the physical and electrical properties of different materials, in order to assist in solving various electric heating problems.

COMMITTEE ON ELECTRIC WELDING

During the year the "newest" activity has been expressed through the Fundamental Electric Arc Research Subcommittee. Choosing the electric arc as the field that required most work, this subcommittee has stimulated interest in the whole corps of men who are doing fundamental arc research. They have pooled the resources of several important work-centers to begin a card-index bibliography that is running into thousands of references. Summaries and translations are planned for all items. When further need arises, fine classification will be undertaken. Further steps of an ambitious program will begin after the bibliography is well consolidated.

The Subcommittee on Power Supply for Resistance Welding Machines has also made substantial progress: two of the three major sections in the Report on Power Supply for Resistance Welders are nearly complete, and the third section is well under way. It is planned to have this report printed late in 1951 so that it can be presented and fully discussed at the 1952 welding conference.

The key organization for the 1952 welding conference has been set up, and preliminary arrangements and program are under way. The meeting will be held in the Rackham Building of Detroit, as before. Subjects will be chosen in relation to the current electrical problems of the industry. Exhibits under the auspices of the American Welding Society are planned to supplement the technical papers. It is expected that the value of the new conference will at least equal that of past conferences, from which some 15 papers have been recommended for publication in *Transactions*. To carry on this work and to arrange for the technical sessions at general and District meetings, there were four committee and eight subcommittee meetings, well distributed around the northeastern industrial sections of the country.

COMMITTEE ON FEEDBACK CONTROL SYSTEMS

The membership of the committee is widely distributed over the United States and Canada, and includes liaison with the Committees on Industrial Control, Mining and Metal Industry, Basic Sciences, Computing Devices, and Instruments and Measurements, and with The American Society of Mechanical Engineers.

The entire committee met once during the year, at the Winter General Meeting. The next committee meeting is planned to be held at the Summer General Meeting. The committee was represented at the forums of technical committee chairmen held at the Fall General and the Winter General Meetings, and at a meeting of specialists to investigate the application of Nyquist's stability criteria to dynamic systems, which was held March 22 and 23, 1951, in Los Angeles, as well as at the meetings of the Industry Division Committee held at the Fall General and the Winter General Meetings.

Subcommittee on Terminology and Nomenclature. During the year four meetings of this subcommittee were held, with representation from the American Standards Association and The American Society of Mechanical Engineers. A progress report was presented as a conference paper at the Great Lakes District Meeting. The subcommittee also plans to have a report published in the July 1951 issue of *Electrical Engineering*.

Subcommittee on Bibliography. In cooperation with a similar subcommittee under the Committee on Industrial Control, this subcommittee is engaged in compiling a bibliography on feedback control systems.

Technical Papers. The committee sponsored one technical session at the Fall General Meeting and two at the Winter General Meeting. In these sessions, nine *Transactions* papers and five conference papers were presented. Interest in this field appears to be lively, as evidenced by the good attendance and discussions at technical sessions and the large number of requests for preprints and reprints of technical papers. The number of papers being submitted for consideration by the committee also appears to be growing, and enough papers are already available for technical sessions at the coming Summer General and Pacific General Meetings.

Technical paper 50-44, "A Frequency-Response Method for Analyzing and Synthesizing Contactor Servomechanisms" by Ralph J. Kochenburger, sponsored by this committee, received first prize in the Industry Group for the year 1950–51. Doctor Kochenburger also received the Alfred Noble prize for 1950.

Conference on Feedback Control Systems. The committee plans to schedule a conference on feedback control systems in the fall of 1951. The conference will afford an opportunity for persons in the industries employing feedback control systems to discuss the state of the art in its many applications.

COMMITTEE ON GENERAL INDUSTRY APPLICATIONS

The committee held a meeting and sponsored a technical session at the Winter General Meeting. The subject was "Electrical Installations in Hazardous Locations." The session was a continuation of a similar session held at the 1950 Winter General Meeting. In addition, the committee sponsored through its subcommittees two technical sessions and three special technical conferences at the Fall General Meeting. These technical conferences followed the pattern set during preceding years in holding technical conferences apart from the general meetings where industrial electrical engineers can meet others in the same or allied fields and discuss electrical applications peculiar to their branch of industry.

Subcommittee on Machine Tools sponsored a 3-day special conference on machine tools in Worcester, Mass., and Springfield, Vt., on November 14, 15, and 16, 1950, and is planning a similar conference to be held in the fall of 1951 in Rockford, Ill.

Subcommittee on Rubber and Plastics Industry has been relatively inactive during the current year due to illnesses among the personnel of the committee. However, the committee is planning a special technical conference to be held in the spring of 1952.

Subcommittee on Textile Industry. A Northern Textile Conference was held in Philadelphia on April 23, 1951, and a Southern Textile Conference in Atlanta on April 26 and 27, 1951.

Subcommittee on Pulp and Paper Industry has been planning a special technical conference to be held in the fall of 1951 in Kalamazoo, Mich. This conference will feature papers on the maintenance and installation problems encountered in this industry.

Subcommittee on Material Handling. Two technical sessions on the application of freight elevators, hoists, and conveyors are planned for the Fall General Meeting. These sessions will prove to be of interest to engineers who have charge of the selection, operation, and maintenance of material handling equipment in industrial plants and coal and ore unloading facilities.

District 7 Subcommittee. Two well-attended and interesting sessions dealing with electrical applications in the oil industry were held at the Fall General Meeting. These sessions were jointly sponsored by this committee and the Induction Machinery Subcommittee of the Committee on Rotating Machinery. A special technical conference consisting of a 1-day program on this same subject is being planned for presentation in the fall of 1951 in Houston, Tex.

West Coast Subcommittee. Two technical sessions dealing with the lumber industry and corrosion and cathodic protection are being planned by this committee for presentation at the Pacific General Meeting.

Other Activities. The subcommittee work discussed does not cover by any means all the industries which come within the scope of the committee. It is planned to add another Subcommittee on Food Processing Industry during the 1951–52 season, and this subcommittee would sponsor technical sessions for 1952 Summer General Meeting.

Conferences. The Committee on General Industry Applications believes the conferences held apart from AIEE general meetings have proved to be of immense value to industrial electrical engineers.

COMMITTEE ON INDUSTRIAL CONTROL

The committee held two meetings and sponsored technical sessions during the Middle Eastern District Meeting and the Winter General Meeting. Plans are under way for participation in the Summer General Meeting and the Fall General Meeting. The following projects have been worked on by the various subcommittees.

Standards Subcommittee is studying graphical symbols for connection diagrams to determine what symbols are needed by industrial users in addition to those now contained in American Standard *Z32.3*. Several symbols have been suggested by the subcommittee to a task group formed by the American Standards Association (ASA) to study symbols for eventual inclusion in an American Standard.

Electronic Control Subcommittee, through its working groups, has completed its work on definitions of electronic control terms. A list of definitions has been submitted to Subcommittee V of ASA Sectional Committee *C42* for inclusion in the pending revised edition of American Standard *C42* "Definitions of Electrical Terms."

Bibliography Subcommittee has completed its work on the "Bibliography on Industrial Control," which has been issued by the Institute as Publication *S39*. The subcommittee is following the contemporary literature on industrial control preparatory to an eventual revision of the bibliography.

Test Codes Subcommittee studied testing methods for behavior of electric contacts. Several papers were sponsored by the subcommittee on that subject for presentation during the Winter General Meeting. Test code sections on endurance and interrupting ability of a-c contactors and on testing temperature rise are under active discussion now.

Regulators and Feedback Control Systems Subcommittee is engaged in developing definitions of technical terms and system classifications which will eventually be discussed with other technical committees active in related fields.

COMMITTEE ON INDUSTRIAL POWER SYSTEMS

At the Summer and Pacific General Meeting, the committee sponsored one session jointly with the Committee on Chemical, Electrochemical, and Electrothermal Applications on problems in the petroleum industry. The committee also sponsored a session at the Fall General Meeting. At the Winter General Meeting, the committee sponsored one session jointly with the Committee on Relays, and two sessions on industrial power distribution, generation, and relaying. The program for a session at the Summer General Meeting is practically complete.

Executive Subcommittee. Only one meeting was held, and all other matters were settled by correspondence. The subject of an industrial power conference for next year is currently under study.

Industrial Plant Grounding. This new subcommittee has held two meetings, with the following subjects assigned to working groups: (a) System Grounding, (b) Equipment and Structures Grounding, (c) Static Grounding, (d) Earthing. It expects to present results in the form of a special publication in 1952.

Distribution Systems for Industrial Plants Subcommittee. This subcommittee, working on revision of the "Red Book," has run into difficulty with one chapter but expects to have it completed shortly.

Distribution Systems for Commercial Buildings Subcommittee. This subcommittee has not been very active since publication of the "Green Book," Special Publication *S30*, last year. About 4,000 of the 5,000 copies printed have been sold to date. Any problems or criticisms will be welcomed.

Load Characteristics Subcommittee. This newly organized subcommittee has little progress to report to date, but plans for study are being formulated.

Power Supply Subcommittee. This new subcommittee was responsible for two papers.

Codes and Standards Subcommittee. This newly organized subcommittee has a double objective, (a) to study and list minimum standards for industrial use, and (b) to keep in contact with AIEE groups working on standards problems to present the industrial point of view, as in the study made several years ago on transformers' voltage rating and taps.

COMMITTEE ON MINING AND METAL INDUSTRY

During the year the committee held two meetings, the first in Cleveland in September, during the fall meeting of the Association of Iron and Steel Engineers, and the second during the Winter General Meeting. The activity of the committee has consisted principally of extending its organization to cover its large field more effectively.

The mining industry is in two groups separated geographically and in center of interest. The first, or eastern group, located generally east of the Mississippi River, has a large majority of its members engaged in soft coal and anthracite mining. The second group consists of the hard rock miners of the West, engaged in mining copper, potash, lead, silver, gold, and other ores. Separate subcommittees were set up during the year for these two groups.

Two technical sessions on mining at the Summer and Pacific General Meeting and a session at the Fall General Meeting were sponsored by this latter group. Due to the great distances in the west, a subcommittee meeting has not been held, and some time will be required to get the organization complete.

A third group associated with both metals and mining operations is that engaged in the beneficiation of taconite. While the work in this field is developing principally around methods and pilot plants, it is expected that large-scale use of electric power will result. No special group has been set up to cover this work.

The two mining subcommittees have been working through their liaison representative with the American Mining Congress, and some work on standards is under way.

The Metals Subcommittee, in sponsoring the technical session at the Summer and Pacific General Meeting on the steel industry in the Los Angeles area and the aluminum industry in the west, reached the interest of the western segments of these two industries for the first time.

The Western (hard rock) Mining Subcommittee and the Metals Subcommittee both will give support to the Summer and Pacific General Meetings.

Liaison is being maintained with the Association of Iron and Steel engineers in the electrical phases of the steel industry.

Due to the geographical distribution of the membership of this committee, its program does not include a technical session at the Winter General Meeting, but a committee meeting is normally held during this session. Technical programs are scheduled for the Summer and Fall General Meetings, where larger attendance from the industries served is expected. With such geographically widespread membership, a directory of committee membership has been prepared for use within the committee giving a biographical sketch of each member.

Based on the experience of the committee since organization, a manual for committee guidance was prepared during the year outlining organization, scope, and procedure. This information is intended to be of assistance to the subcommittees and incoming officers.

Power Division

COMMITTEE ON CARRIER CURRENT

This committee held two meetings during the year, and plans to call similar meetings on a flexible schedule as required by the work in process. The committee sponsored technical conference sessions on carrier current matters and on microwave applications at the Summer General Meeting.

Full advantage was taken of contacts established with individuals on the West Coast to publicize the activities of this group and to solicit co-operation from interested parties. A vice-chairman representing the West Coast was appointed, and has been most effective in administering the activities among members in that part of the country, particularly in planning technical sessions at District meetings and bringing in new members.

Power-line carrier, in general, is being called upon to assume greater burdens as power systems expand through the addition of new plants, lines, and substations. This, with the tendency toward automatization, requires more channels such as power-line carrier for the burden of conveying telemetering, supervisory control, load control, and relaying signals, in addition to voice communication.

As in the past, the major part of the work has been carried on by subcommittees, each of which has followed actively its assignment.

Subcommittee for Preparation of a General Interest Paper. The work of this group has been completed and the subcommittee will be discontinued.

Subcommittee to Report on Application Guidance for Carrier Current. The work of this group is nearing completion.

Subcommittee on Methods of Measurement is studying further simplification of methods, attempting to make them fool-

proof, plans to provide more detail in measurements of line characteristics, and will draw up a list of the most suitable instruments for this work.

Subcommittee on High Frequency Characteristics of Power Equipment is making measurements in factories whenever the opportunity presents itself.

Subcommittee on Carrier Current Characteristics of Transmission Lines and Systems has assembled considerable data through a questionnaire and is now busy analyzing these data.

Subcommittee on Long-life Tubes is gathering information from all possible sources and will consider, in addition, tube life in microwave service.

Subcommittee on Use of Microwave Equipment for Relaying, Telemetering, and Supervisory Control. Microwave applications are fast approaching the status of an exact science, such that it is possible to predetermine performance and provide any desired order of reliability. The committee is actively in touch with all developments and will consider methods of co-ordinating with existing facilities such as power-line carrier.

Subcommittee on Operating Experience with Carrier Current Relaying Channels has assembled much information from a questionnaire and a preliminary report is in preparation.

Other Activities. A bibliography of technical material on power-line carrier is in preparation. Liaison has been maintained during the year with the Committee on Radio Communications Systems, the Committee on Relays, and the Committee on Transmission and Distribution.

The committee is planning to hold a symposium in the near future, consisting basically of: (1) One or more papers expressing the general position of power-line carrier and its value in the industry, (2) A history of the evolution of power-line carrier, as produced by the subcommittee for preparation of a general interest paper, and (3) Present status and application guide, as produced by the Subcommittee to Report on Application Guidance.

In general, the committee thinks that, judging from the interest shown, there is an adequate demand for work of the type which it has undertaken, and it is hoped that even more rapid progress can be made in the coming year.

COMMITTEE ON INSULATED CONDUCTORS

The committee has continued its active program through a total of some 90 members and special members and two regular meetings, besides special meetings of subcommittees.

Some progress has been made regarding a number of subjects during the past year, including the following: thermal characteristics of cable installed in conduit and of pipe-type cable systems; methods for determining effects of cable movement on life of sheath in manholes and the use of lead-alloy sheaths to obtain increased life; practices on vertical-riser cables; accessories for insulated wires and cables; bibliography on insulated conductors; impulse testing; and characteristics of synthetic insulations.

In addition to continuing the development of a good number of desirable papers during the past year, the committee has in prospect a fairly large number of worth-while papers for the coming year.

COMMITTEE ON POWER GENERATION

The committee held two meetings, one at the Fall General Meeting and the other at the Winter General Meeting. The activities of the committee, as reported by the various subcommittees, are as follows:

Prime Mover. A session was organized by this subcommittee for the Fall General Meeting, at which recent advances in the control of gas turbines for power generation, thrust bearing problems, and hydrogen cooling problems were discussed.

Station Design. Through the efforts of this subcommittee, a session was organized for the Winter General Meeting on the co-ordination of station design and analysis of plant operation troubles. Recent developments in power generation were discussed, together with needed improvements in stations and machines. This subcommittee is sponsoring a symposium on "Needed Improvements in Power Stations" for the 1952 Winter General Meeting.

Speed Governing. This subcommittee is now obtaining experience data on the governing and control of modern reheat steam units. These data will later form the subject of a report. Progress has been made by this subcommittee jointly with the Excitation Subcommittee in the compilation of terms and definitions.

Excitation Systems. This subcommittee organized a session for the Summer General Meeting, at which papers were presented discussing excitation experience and recent developments.

Application of Probability Methods. A session on hydroelectric plant reserve practices was sponsored by this subcommittee during the Winter General Meeting. Papers sponsored by this subcommittee made contributions to the problem of evaluating reserve savings from interconnections. The subcommittee is now exploring the possibility and desirability of further investigating the effect of station layouts on reserve capacity.

Hydroelectric Systems. A session on underground electric plants was sponsored by this subcommittee at the Summer General Meeting, in which the possibilities of underground generation were explored.

Other Activities of the Committee on Power Generation are: The committee has agreed to participate in the American Society of Civil Engineers Celebration of Centennial of Engineering in Chicago, September 1952, by sponsoring two or three papers. The committee is studying factors affecting economics of generation, and is planning a session on Power Generation Economics for the 1952 Winter General Meeting.

COMMITTEE ON PROTECTIVE DEVICES

The Committee on Protective Devices has sponsored two technical sessions, one at the Winter General Meeting, and one for the forthcoming Summer General Meeting. The committee held a meeting during the Winter General Meeting. The activities of the committee are primarily carried on by three subcommittees. The reports from these subcommittees are as follows:

Fault Limiting Devices. Application guides covering the grounding of synchronous generating systems, the method of grounding transmission systems, and the application of ground-fault neutralizers were presented at the Summer and Pacific General Meeting. These guides have been presented as Advance-Copy-Only papers and issued on a trial basis. The committee has now received comments from the membership, and has started to revise the guides to place them in final form.

The Power System Fault Limitation Working Group completed its report, which was presented at the Winter General Meeting. A survey is being conducted jointly with the Committee on Industrial Power Systems to determine present grounding practices on industrial systems. This survey will determine if there is any accepted practice or agreement in the connection of the power system neutral, that is, whether the neutral should be grounded through a resistor, a reactor, potential transformer, ground-fault neutralizer, or a combination distribution transformer and resistor.

The subcommittee has the following projects under consideration: (a) A project to set forth the factors relative to the necessity for shunting resistors or lightning arresters across reactors used for feeders or generator neutrals, (b) A project to outline the factors which determine the size and rating of grounding transformers, and (c) A project on grounding of voltage regulators on power systems.

A survey is being made jointly with the Committee on Substation Grounding to determine the present-day practices on substation grounding.

Lightning Protective Devices. The Lightning Protective Devices Subcommittee has continued its efforts to unify and co-ordinate information relating to performance characteristics, testing, and application of lightning protective devices. A major step in this program was the publication of the report on the Combined Standard for Valve and Expulsion Arresters, AIEE *28A*. This report has been out for one year, and the working group which developed it has been reactivated to study its effectiveness in the field and to consider recommendations for amendment or modification. The specification of recovery voltage conditions under which power tests of lightning arresters shall be made also will be undertaken at this time, since the necessary information has become available recently.

The performance characteristics of all types of lightning arresters are being reviewed to determine the advisability of issuing a revised report to include new makes of lightning arresters which have entered the field since the last report and the new reduced tolerances which have been established for certain types of lightning arresters.

One of the major projects remaining on the agenda of this subcommittee is that of the Application Guide for the Protection of Substations. This difficult work is nearing completion, and a preliminary report has been scheduled for the Summer General Meeting. Lack of agreement on some points and lack of necessary data have delayed this project considerably. However, recent AIEE papers have made available much of the awaited in-

formation, particularly that relating to distance effects between the protective device and the object to be protected. A survey is now under way to determine the extent and effectiveness of the practice of direct stroke shielding of substation and associated lines. This information is needed in order to complete the recommendations to be included in the application guide.

The agenda of the subcommittee includes the following suggestions which have been submitted for its consideration: co-ordination of methods for determining radio influence; rod-gap characteristics in the short-time region; protection of aerial cable; and dry-type transformers.

Co-ordination of Insulation. This subcommittee was formed primarily to keep the members of the main committee informed as to the progress that is being made by the Triple Joint Committee (consisting of EEI, AIEE, and NEMA delegations) on the co-ordination of insulation. For this reason it has not required the establishment of working groups.

COMMITTEE ON RELAYS

The committee held three meetings and sponsored three technical sessions. The technical activities of this committee were carried on through a number of project committees which were appointed to fulfill specific assignments. Following are the reports of the various project committees:

Generator Protection. This committee has completed its investigation of the various methods of a-c generator protection used in this country and Canada. On the basis of a survey made last year, a report was prepared recommending practices preferred for application to new installations, which was presented at the Winter General Meeting. The committee report and the discussions of it have been released for publication in the *Transactions*.

Bibliography of Relay Literature. This project committee presented a "Bibliography of Relay Literature, 1947–49" at the Winter General Meeting. The committee will continue to maintain an up-to-date bibliography in future years.

Co-ordination of Construction and Protection of Distribution Circuits. This project committee is a joint working group of the Committee on Relays, the Distribution Subcommittee, and the Edison Electric Institute Transmission and Distribution Committee.

This working group is now in the process of writing a first draft of a report on the Performance of Distribution Circuits from which operating data were obtained for the year 1949. The report will contain information relative to the number of faults occurring on these circuits and a breakdown of the causes of these faults into the number initiated by lightning, glaze, wind, trees, and other causes. It also will contain information covering the performance of different types of protective devices in preventing faults of a temporary nature from becoming permanent. The first draft of the report is not yet complete, but it is expected to be finished and available for the Fall General Meeting.

Standards for Power Relays. In 1949 this committee completed a revision of ASA Standard *C-37*, American Standard for relays associated with electric power apparatus. During the past year considerable information was gathered on performance specifications which will ultimately be added to the present Standard ASA *C37.1*. In analyzing the material, it became apparent that this phase of the work fell outside the scope of the Committee on Relays, and steps were taken to have a committee in the National Electrical Manufacturers Association take on this phase of the Standard. Such arrangements were made, and a committee is now actively engaged in preparing performance standards for relays.

Transmission-Line Protection. The project committee on transmission-line relaying has as its objective the preparation of a report describing current practice and trends of thinking in transmission-line protection. In order to develop material, two conference sessions and one technical session have been sponsored, and a questionnaire on backup practice has been distributed and replies analyzed. There is still lacking an adequate paper on ground relaying, and a further single question on backup relaying is to be circulated to members of the main committee. Arrangements are being made for a paper on ground relaying and one on backup relaying. When these are available, it will be possible to prepare a final report of the project committee.

Electronic Relay Applications. This project committee was relatively inactive during the past year, its principal function being to follow developments in electronic protective relays. Developments in this area consisted mainly of the use of microwaves in transmission-line relaying and in transferred tripping. New developments in transferred tripping via carrier current are being reported by another project committee.

Relaying of Interconnections Between Industrial and Utility Generating Systems. This project committee, in co-operation with the committee on Industrial Power Systems, sponsored a conference session at the 1951 Winter General Meeting. The project committee presented a conference paper at this session which was based on a questionnaire on the practice of utility-industrial relaying that had been answered by 32 companies. There has been some discussion of the presentation of additional papers on practices of the relaying of interconnecting transmission lines between industrial and utility systems.

Pilot Wires. A questionnaire has been prepared by this committee for circulation to the industry to obtain information relative to operating experience with pilot wire circuits, leased and privately owned, used for protective relays. The questionnaire covers the years 1942–1950 inclusive. It is proposed to prepare a report summarizing the information obtained from the answers to this questionnaire.

Remote Tripping Schemes. The objective of this committee is to collect information on remote tripping schemes and the operating experience that has been obtained. A questionnaire has been prepared, and has been sent to various operating companies, requesting data on the design of equipment that has been installed and on operating experience. The results obtained from this questionnaire will be presented to the Institute in the near future.

Test Methods. This committee has been collecting data from available sources on portable field testing equipment suitable for testing the majority of the more complicated types of relays. The data are being reviewed by the project committee, and it is expected that eventually information on this equipment will be presented to the Committee on Relays.

Consideration is being given to the sponsorship by this committee of a conference session at one of the 1951–52 general meetings. This will make possible an exchange of ideas on test methods and test equipment.

Effect of Vibration and Shock on Relays. This committee was formed to study the effects of vibration and shock on relays used in electric power systems in industrial applications. Some progress has been made in the study of existing installations by making actual measurements of available equipment. A questionnaire has been circulated covering the troubles that have been experienced with relays in existing installations. From the information which is being obtained from various sources, the committee proposes to prepare an Institute paper offering a suggested guide which should be useful to the industry in designing and applying protective relays to avoid difficulty from shock and vibration.

Joint and Associated Projects. The committee participates in the activities of the Instrument Transformer Subcommittee of the Committee on Transformers, with special attention to the relaying performance of current transformers and the transient performance of capacitance potential devices. The latter committee has been very active this past year in examining the problems associated with the use of capacitance potential devices for relaying purposes. The Committee on Relays has maintained close co-ordination with the activities of the Committee on Carrier Current on items of joint interest.

COMMITTEE ON ROTATING MACHINERY

The committee held a meeting during the Winter General Meeting. Committee activity is largely carried on by correspondence and through its subcommittees. The outstanding feature of this year's activity was the group of sessions on insulation at the Winter General Meeting. This old subject needed only an outlet to bring out a torrent of 15 papers on insulation. It is expected that, with present rapid developments, insulation will be an active subject for several years.

One new subcommittee is being formed to cover magnetic fluid couplings and clutches, the magnetic particle clutch, electric coupling, eddy current coupling, eddy current brakes, eddy current dynamometer, and electrically operated friction brakes where the magnetic circuit is part of the brake itself, but to exclude electrically operated friction brakes and clutches where the electrical part is simply a magnet of solenoid providing a pull to operate a completely mechanical device.

Synchronous Machinery Subcommittee. Seven papers were processed and presented. Revisions have been recommended in the test code, and under consideration is a new

method for testing subtransient reactances. The first draft of the synchronous section of the revised ASA *C-50* has been received for review. Under consideration is the upward extension of standard voltage ratings for synchronous generators above 90,000 kva. Papers may be solicited on this question.

Insulation Subcommittee. An unusually successful group of sessions was held at the Winter General Meeting. Future projects include a-c and d-c overvoltage testing values for machines in service, overvoltage testing of turn to turn insulation, and a review of classifications of insulation in AIEE Standard *1*.

Induction Machinery Subcommittee. Test Code Number *500* is now almost completely rewritten. Copies of the revised draft will soon be available for general committee review. A symposium has been suggested on the application of motors with particular emphasis on papers of value to the users of motors.

D-C Machinery Subcommittee. Active work is being done on transients and short-circuit currents in d-c machines. Similar work on flashover is being considered. Transients and protection of d-c systems on aircraft are also on the agenda.

Single-Phase and Fractional Horsepower Subcommittee. A special technical conference will be held in Dayton October 11 and 12, 1951. Application of small motors to refrigeration and pumps is the main topic for this session, which is jointly sponsored with the Domestic Appliances Subcommittee. The test code is being actively revised, still requiring correlation with the master test codes.

Test Code Co-ordinating Subcommittee. This committee is working actively with the ASA *C-50* committee toward revision of test codes so as to be directly usable in the test code section of ASA. Requests have been made for master test codes for radio noise measurement and for speed measurement.

COMMITTEE ON SUBSTATIONS

The status of the projects on which work is in progress in the subcommittees and working groups of this committee is described here.

Automatic and Supervisory Control Subcommittee. This subcommittee concluded work on rectifier reclosing control problems, grounding practices on d-c switching structures, and protection of conversion units feeding high capacity d-c busses.

Distribution and Conversion Substations Subcommittee. The project on "Bus Regulation versus Feeder Regulation" finally culminated in a set of papers at the Winter General Meeting. This project is now closed. Work is still continuing on the project covering "Breakers versus Reclosing Fuses" and "Basic Structural Design of Outdoor Stations." Projects on "Lighting of Substations" and "Standardization of Factory Designed and Constructed Substations" are being pursued to some extent.

Transmission Substation Subcommittee. A report on a project covering "Basic Structural Design of Substations" is expected to be ready soon. Little progress has been made on the "Safety Considerations in Substations" project.

Device Function Numbers Working Group. No activity was necessary during the year.

Substation Grounding Practice Working Group. A questionnaire was circulated and replies are now being studied. A report is forthcoming.

Rectifier Switchgear Working Group is studying grounding practices and recommendations for d-c switchgear in outdoor substations.

Committee Meetings. In addition to meetings of the subcommittees and working groups, meetings of the main committee were held in Pasadena in June 1950, and in New York in January 1951. A technical session under the sponsorship of the committee was held at the Winter General Meeting.

COMMITTEE ON SWITCHGEAR

The activities of the committee have largely comprised work on revision of present AIEE Standards *20, 25, 27,* and *50*.

Proposed Standard *20A* on Low Voltage Air Circuit Breakers was published in December 1946, and is still on a trial basis. A complete revision of this standard was approved by the committee on October 17, 1950, and submitted to the Standards Committee on November 21, 1950. No action has as yet been taken by the Standards Committee, but it would seem very desirable to get this standard issued as speedily as feasible, since the present Standard *20* was issued in 1930.

Work is in progress on a revision of Standard *25*, "Fuses above 600 Volts." The subcommittee working on this expects to have the work completed shortly.

A complete revision of Standard *27* on Switchgear Assemblies was also approved by the committee at the October 17th meeting, and submitted to the Standards Committee on November 24, 1950. Action on this standard is very much desired since a considerable amount of new material is contained in the revision which did not appear in the present standard issued in August 1942. The addition to Standard *27* of Standards to cover isolated phase busses is now under consideration.

Proposed Standard *50* for Automatic Circuit Reclosures issued in September 1949 for trial use is being worked on for submission as an approved standard. This work is progressing nicely, and it is hoped that it will be ready in the near future.

It is expected that revisions to Proposed Standards *22A* on Air Switches, Insulator Units, and Bus Supports, issued for trial use in October 1949, will be ready for action during the coming year. A working group is being organized for the purpose of preparing a standard for ice testing of disconnecting switches.

The Circuit Breaker Subcommittee has also completed the work of making revisions in ASA Standard *C-37* on Power Circuit Breakers. This has involved co-operation with other interested committees and standardizing bodies. These proposed changes will be presented shortly for approval. A Test Code for Power Circuit Breakers and one for Low Voltage Air Circuit Breakers are being prepared.

Two committee meetings were held. The committee sponsored one session at the Fall General Meeting and one at the Winter General Meeting. One joint session was also held with the Committee on Transmission and Distribution on the subject of capacitor switching at the Winter General Meeting.

During this year a new subcommittee was formed to consider the design and application of network protectors. The need of some standardization for generator voltage regulators is also being given some consideration by the Switchgear Assemblies Subcommittee.

COMMITTEE ON SYSTEM ENGINEERING

This committee is about to finish its fourth year of existence, and is continuing its original subcommittee organization, which is: (1) Administrative; (2) System Planning; (3) System Operation; (4) System Economics; (5) System Controls; and (6) Interconnection Contracts.

The committee's technical program for the year ending April 30, 1951, began with a session on system planning at the Summer and Pacific General Meeting. During the year it conducted a number of technical and conference sessions on the subjects "The Effect of Low Voltage and Low Frequency on Power Plant Auxiliaries" and "Determination of Reserve Capacity by the Probability Theory"; and a symposium on "Determination of What Units in What Plants should be Used for Loan and Frequency Control."

Three committee meetings were held, an all-day meeting in Chicago on May 4, 1950, with separate subcommittee meetings as part of the agenda, and meetings at the Fall and Winter General Meetings.

In conformity with the committee's general plan of having a subcommittee sponsor a technical session for an individual general meeting, the System Economics Subcommittee is preparing for a session at the Fall General Meeting dealing with the general subject of "What the Basic Factors Should be for the Comparison of Alternate Facilities." The System Planning Subcommittee has undertaken to arrange for a program for the Winter General Meeting.

COMMITTEE ON TRANSFORMERS

The committee has progressed in the various topics under investigation, as indicated by the following reports:

Co-ordinated Study of Life of Transformer Insulation Working Group. A progress report dealing with the co-operative tests on aging of high-temperature insulations was presented at the Winter General Meeting. All of the technical difficulties of getting this started have now been completed, and the tests are under way.

Joint Working Group on Instrument Transformers. A report on the changes in the standards for instrument transformers was presented at the Winter General Meeting. The report deals with the clarification and modification of ASA *C57.13* and *C57.33*. A paper on the study of transient characteristics of potential devices is now complete and will be presented at the Sumnser General Meeting.

Magnetization Characteristics of Transformers Working Group. The work of

this group was presented at the Winter General Meeting. It deals with magnetization characteristics, relaying problems associated with excitation current of transformers, and a survey of air switch practice.

Revision of Dielectric Tests Working Group. A report on the activities of this working group was presented at the Winter General Meeting. The group has submitted a report to the Committee on Transformers for approval.

Guides for the Operation and Maintenance of Dry Type Transformers with Class-B Insulation Working Group. A complete report of this group's activity was submitted at the Winter General Meeting. The group is now awaiting letter-ballot approval by the main committee. This report covers an entirely new field of investigation.

Co-ordination of Insulation Working Group. Work in this group has been completed for the 115-kv basic-impulse-insulation-level range and higher.

Methods of Making Temperature Tests Working Group. The work of this group consisted of general revision of ASA *C57.22* and was issued as a preliminary report at the Winter General Meeting for comments. The report has been revised and the final report will be submitted to the main committee for approval.

Audible Noise in Transformers Working Group has been enlarged to include those having field experience now that the method of conducting the study has been completed. Work is progressing satisfactorily.

Hot Spot Temperature Rise of Class-B Reactors Working Group. The trial period for the 110-degree centigrade hot spot, set more than a year ago, has now expired and this subject will be reviewed again, taking into account all the comments received.

Permissible Maximum Oil Temperature Rise in Service Working Group has almost completed a report which will be issued shortly.

Insulating Fluids Working Group is a new group formed this year to study and make recommendations on some of the problems in which insulating fluids are involved.

COMMITTEE ON TRANSMISSION AND DISTRIBUTION

Considerable progress has been made during the past year in the several fields of activity within the committee scope, through the planning of the main committee, the efforts of the subcommittees, and technical papers which have been presented at practically all the major general meetings of the Institute.

In the lightning and insulator field, the Lightning Bibliography covering 1936–1949 was completed and made available in pamphlet form at Institute headquarters. Copies of this are still available for those who now are, or later expect to be, interested in this field. The committee report on predetermining the lightning performance of transmission lines has been completed and published. Experience in insulator washing under contaminated atmospheric conditions and considerations of insulation co-ordination were presented in papers at the Middle Eastern District Meeting. Other papers on lightning performance of transmission lines have been presented, or are in prospect at the present time.

In the power capacitor field, papers were presented at the Winter General Meeting dealing with features of design and operation of large capacitor banks. A bibliography on this subject is now in the course of preparation. The application of series capacitors to high-voltage lines is to be treated in a series of papers at the Pacific General Meeting.

In the distribution field, a report on rural-line sectionalizing was presented at the Winter General Meeting, and a presentation on economics of primary design is planned for the Summer General Meeting.

Conductor vibration on high-voltage lines has received considerable attention in the Towers, Poles, and Conductors Subcommittee, and a comprehensive symposium was held at the Fall General Meeting. Discussion, work, and further consideration on this subject are still going on. Another subject in which there is considerable interest at the present time is the possibility of more heavily loading transmission-line conductors.

Of outstanding interest during the past year has been the presentation of field test results on corona and radio influence as determined on an experimental high-voltage line operating as high as 525 kv. As a result of these field tests, extending over some three years, the announcement has come of a new high-voltage line designated as 300/315 kv, which probably will operate as high as 345 kv, phase-to-phase. Sections of this line are now under construction.

Looking to the future, the work in the committees of particular interest is: (1) The joint study with the Edison Electric Institute on line outage experience of high-voltage lines over a large part of the country, on which a preliminary report will be presented at the Summer General Meeting; (2) An investigation of rates-of-voltage rise on distribution systems which will be of use in applying lightning protective devices; (3) A study of lightning insulation characteristics of wood, air, and porcelain in series; and (4) Application of series capacitors on high-voltage systems.

The committee is continuing to function, as in the past, with the main committee acting as the discussion and advisory group, where all matters of importance and significance are presented and discussed and then delegated to the subcommittees for the constructive action and carrying through to a conclusion. In addition to the specific work carried on by the committee itself, there have been quite a number of technical papers offered to the committee on more general, but related, subjects. These have been reviewed and processed for publication, or other disposition as recommended. To date, there is no backlog of approved technical papers in the committee which have not been scheduled for publication.

Science and Electronics Division

COMMITTEE ON BASIC SCIENCES

The Committee sponsored eight papers describing advances in the theory of transmission circuits at the Winter General Meeting. The committee also held a meeting at which decisions were taken to establish a Subcommittee on Dielectrics and a Subcommittee on Defense.

It has long been thought that the Subcommittee on the Electrical Properties of Solids and Liquids has too broad a field and that the subject of dielectrics could be properly isolated from this general field and considered apart from metals and semiconductors. Accordingly, the new subcommittee on dielectrics is to have the following scope:

> To foster and promote symposia on the basic aspects of the electric insulation field, to disseminate information on progress being made in the fields of dielectric theory and practice for the general purpose of serving the design and development engineer who will eventually apply this information to practice, to bring to the Institute some of the results of the activities of the National Research Council conference on electric insulation.

The members of the Committee on Basic Sciences, after a talk by Colonel W. M. Young on the problems of the armed services, decided that a Subcommittee on Defense to help the armed services with the basic technical problems should be established with the following scope:

> To make available to the armed services such information on the basic sciences that would expedite their efforts in the solution of defense problems, and to cooperate with the armed services in whatever way they desired in order to strengthen the defense of our country.

It was suggested that three members of the armed services—one from the Army, one from the Navy, and one from the Air Force—be invited to become members of this subcommittee and that the subcommittee recruit as members several civilian experts in various fields of basic knowledge.

The work of the Committee on Basic Sciences is unique. It not only promotes advances in the fields already familiar to the profession but also attempts to acquaint engineers with new developments in the fields of physics and mathematics which are of interest to the profession. Hence, besides these newly established subcommittees, the Committee on Basic Sciences sponsors and co-ordinates the activities of six other subcommittees. The reports of the chairmen of these subcommittees follow.

Subcommittee on Magnetics held one meeting in 1950, and arranged for a symposium on "Magnetic Materials at High Frequencies" which was held during the Winter General Meeting, with four invited papers, and was well attended. Two of the papers are to be published in *Electrical Engineering*. Another project of the subcommittee has been to prepare a list of people in this country who are actively interested in magnetism. The list now comprises about 150 names and is a help to the subcommittee in its work; it is available to members of the Institute. A number of Institute papers on magnetism have been reviewed.

Subcommittee on the Electrical Properties of Solids and Liquids sponsored a conference during the Winter General Meeting at which four conference papers dealing with the properties of semiconductors were presented. The purpose of these papers was to acquaint the profession with new developments in the field of semiconductors. Interest in this field was shown not only by the attendance but also by the discussion of the papers.

Subcommittee on Electric Circuit Theory presented a symposium at the Winter General Meeting on "New Techniques of Network Synthesis," at which four outstanding specialists in network theory presented invited papers. The talks were concerned with the generation of functions suitable for network synthesis and the construction of realizable networks therefrom. The session was well attended and the interest in the papers was manifested by the energetic discussions which took place. At a later meeting of the subcommittee, it was decided to consider the publication of a pamphlet which would contain selected papers presented at this symposium and other successful network symposia held in the last two years. Further, it was decided that, in view of the success of the symposium at the Winter General Meeting, a similar session would be organized for the Fall General Meeting.

Subcommittee on the Electrical Properties of Gases held three meetings. The primary purpose of the first two meetings was to complete plans for a technical conference on electrical breakdown in gases, which was held during the Winter General Meeting, with four conference papers presented. The conference was well attended, and interest in this general topic was shown through the discussions which followed it. The subcommittee also held a meeting of its membership for the purpose of planning a program for the 1952 Winter General Meeting. The tentative subject of this conference is fundamental processes in gas discharge tubes. The subcommittee also reviewed several papers.

Subcommittee on Applied Mathematics has tried to implement the program it proposed during the last year whereby a group of mathematicians would be made available for the solution of problems presented by the AIEE membership. In order to popularize the program, the chairman of the subcommittee published an article in *Electrical Engineering* outlining the proposal and inviting Institute members to take advantage of the free services offered by the mathematicians who were made members of the subcommittee. So far, only four problems have been submitted, and these have been referred to the mathematicians for solution. It is sincerely hoped that more Institute members will take advantage of the opportunity to avail themselves of the free services of outstanding mathematicians.

Subcommittee on Energy Sources held a meeting and sponsored one conference, its fifth, on energy sources during the Fall General Meeting. It is planned to have the sixth conference on energy sources during the 1952 Winter General Meeting.

COMMITTEE ON COMPUTING DEVICES

Work in the field of large-scale computing has progressed rapidly during the year, and many of the projects and applications which were plans only a few years ago have now been achieved, or appear close to achievement. The large-scale computer field has two important aspects: research and development in the production of large-scale computers, and the applications of these machines. In research and development, there have been many improvements, and former potentialities, such as high-speed memories having far greater capacities than even thought of several years ago, now appear to be rather definite possibilities.

In the field of application, there are over and above the applications in the physical sciences for computing, control, and so forth, important applications both present and potential in number theory, mathematical table making, analysis of large-scale data in the field of statistics, business applications, and management applications, as well as a large group of miscellaneous potential uses sometimes of a rather unusual character. In number theory, there have been computations carried out in certain cases which have in a short time doubled all the work done in past years. In table making, the tables issued by the Harvard Computational Laboratory and by others have substantially shown that the big machine is taking over this complete field as far as major projects are concerned. In the handling of large amounts of data, probably the most important single test will be the use of the large electronic machine being built for the Bureau of Census and now nearing completion. If this proves a success, it should be the forerunner of a large number of others for similar applications.

In the field of business, planning usually proposes combining many procedures and making automatic many manual operations by means of large-scale computers, with much saving in time and in cost indicated. In the field of management, problems of the logistics type which often can be linearized into a multitude of simultaneous equations may be handled on large-scale computers to obtain optimum results. One machine for this particular purpose is now being constructed. In addition to all these, there are the simulators and other large special purpose machines, both analogue and digital, the use of which has increased greatly in the last few years. One paper presented an application of a small computer to an economic problem, and it is known one of the Armed Services is actively investigating the use of large-scale computers for determining effects on the entire economy of major changes in industrial requirements.

The Committee on Computing Devices has thought that one of its primary duties is to perform an educational function by calling the attention of members to the computing machine field. To this end, it arranged one or more sessions each at the Summer, Fall, and Winter General Meetings, as well as at three District meetings, and has under way plans for sessions at the 1951 Summer and Pacific General Meetings.

The subcommittee on preparation of a bibliography is preparing a bibliography of a basic character which, though it will not be long or comprehensive, will be selective and of the type which is hoped will enable a fast review of progress to date with a minimum of effort. This bibliography should be available as an AIEE publication during the coming year.

The Committee on Computing Devices was joint sponsor of the conference on electron tubes for computers, held in Atlantic City in December 1950. The committee has an active subcommittee which has taken the initiative in preparing plans, jointly with IRE and Association for Computing Machinery for another conference, probably to be held late in 1951.

COMMITTEE ON ELECTRONIC POWER CONVERTERS

The committee activities have consisted mainly of the preparation of reports summarizing available information and outlining recommended practices, and the presentation of papers describing new developments and applications of interest. One technical session was held at the Summer and Pacific General Meeting, and a conference session on "New Types of Rectifiers" was held at the Winter General Meeting.

Plans for the year were outlined at a meeting of the Administrative Subcommittee held on October 16, 1950, in New York. A meeting of the committee was held during the Winter General Meeting. The committee also met with the Electron Tube Subcommittee of the Committee on Electronics at a joint luncheon meeting on the same date.

The following progress has been made on the various committee projects:

Report on Inductive Co-ordination Aspects of D-C Systems Supplied by Rectifiers. This report has been completed, and it is scheduled for presentation at the Summer General Meeting and publication in *Transactions*. It was prepared by a working group of the Subcommittee on Applications.

Bibliography on Electronic Power Converters. The Subcommittee on Papers and Speakers has begun the preparation of a supplement to the Bibliography for the years 1948, 1949, and 1950.

Standards for Hot-Cathode Power Converters. The Subcommittee on Hot-Cathode Power Converters has prepared a list of definitions for hot-cathode power converters. It is presently engaged in preparing material for sections of standards and test code.

Report on Rectifier Cooling and Corrosion Problems. A working group has been appointed to prepare a report summarizing the available information on rectifier cooling and corrosion problems and outlining recommended practice. It is expected to complete the report sometime within the next year.

Conference on Power Tubes in 1952. The Committee on Electronic Power Converters and the Electronic Tube Subcommittee of the Committee on Electronics are planning to sponsor a joint conference on power tubes in April or May, 1952. This will be a 2-day conference, and is expected to draw an attendance of 200 or more. Committees are now engaged in selecting a location and planning the program.

West Coast Subcommittee. This subcommittee is planning to hold a technical session at the Pacific General Meeting. It is soliciting papers of particular interest to rectifier users.

Subcommittee on Mechanical Rectifiers. In view of the continuing development and growing application of mechanical rectifiers, it has been decided to form a new Subcommittee on Mechanical Rectifiers.

COMMITTEE ON ELECTRONICS

The committee has continued to support specialized 2- or 3-day conferences in specific work areas. Such meetings during the period covered by this report have been:

A 3-day symposium on improved quality electronic components in Washington, D. C., in May 1950.

The third annual joint conference on electronic instrumentation in nucleonics and medicine, held in New York in the fall of 1950.

The annual conference on electron devices, held at the University of Michigan, Ann Arbor, in June 1950. This was sponsored jointly by the IRE Committee on Electron Tubes and Solid State Devices and by the Subcommittee on Electron Tubes of the Committee on Electronics. The attendance was excellent. This was in a sense an experiment on the part of the AIEE group, as for many years this conference has been an annual affair operating entirely within the IRE organization. The 1950 conference represented a very satisfactory co-operative effort.

A 2-day conference on electron tubes for use in electronic computing devices, held in Atlantic City in December 1950.

National Electronics Conference (NEC). This 3-day conference, held annually in the fall in Chicago, is a very large middle-western forum for the presentation of papers of electronic interest, incorporating an extensive manufacturer's display of electronic instruments and new products; the *Proceedings* of the NEC, published annually, contains in complete form the papers presented at the NEC. The Committee on Electronics has continued the policy of giving substantial support to the NEC. During the calendar year 1951, the Chairman of the committee is also serving as Chairman of the Board of Directors of the NEC.

Active plans are currently under way for the following conferences:

A conference on electron tubes for power conversion in industrial control equipment, somewhat similar to the one on electron tubes held in Buffalo in the spring of 1949.

The annual electron devices conference, to be held in June 1951 at the University of New Hampshire.

The conference on electronic instrumentation in nucleonics and medicine has become well established as an annual affair, and plans are in process for holding it again in December 1951.

Meetings of the committee were held at the Summer and Pacific General Meeting; at the National Electronics Conference; and at the Winter General Meeting.

At the fall meeting in Chicago, the primary subject of discussion was the question of the appropriate size for the committee, in view of the objectives it is pursuing. As a result of the discussion, the committee concluded that it is not desirable to separate the electron tube subcommittee activity, because of the very great profit that accrues both to the electron tube group and the circuit activities represented in the committee by their mutual association and contact. Also, it became quite apparent that the committee represents not only activities in very special fields requiring specialized talent for their carrying-out but also serves as a valuable forum for the exchange of opinions and judgments as to the proper future program of electronics activities within the AIEE. Thus, many of the members of the committee are valuable because of the responsibility they feel toward giving advice and counsel to the group as a whole and in helping to orient its program, even though their present participation in work activities is modest.

As to organization, the committee has two types of subcommittees: subcommittees active in special technical fields, and subcommittees having specific functional interests relative to all technical aspects of the committee's work.

The following are the subcommittees in special technical fields.

Electron Tubes. This subcommittee has working groups engaged in the preparation of standards and program planning as follows: (1) High Vacuum Tubes, (2) Cathode-Ray Tubes, (3) Hot-Cathode Gas Tubes, and (4) Mercury-Pool Tubes. It was responsible for two technical sessions at the Winter General Meeting. One of these dealt with radiation detection devices and the other with power tubes for electronic heating. Both sessions were concerned primarily with the design phases. The subcommittee has active working groups on mercury-pool tube standards, and is working on standards for radiation detection devices. It was the responsible agent of the main committee for the 2-day electron devices conference in June 1950 and for the 2-day conference on electron tubes for computers in December 1950.

X-Ray Tubes, Apparatus, and Applications. This subcommittee held three meetings during the year, under environments permitting close association with members of the major societies of medical radiologists. A 5-paper symposium on X-ray equipment and applications was held at the Winter General Meeting, jointly sponsored by this subcommittee and the Committee on Therapeutics. As to standards, a report on X-ray tube graphical symbols has been completed, and the work on definition of terms is being carried forward; it is hoped that this will be completed during 1951. The next study will be that of specifications of characteristics and ratings of tubes used for X-ray equipment.

Electrostatic Processes. This subcommittee arranged two programs involving interesting demonstrations for the Winter General Meeting in January, and has completed arrangements for a technical session at the Summer General Meeting. The standards activity, initiated as an outgrowth of a conference paper presented in January 1950, is continuing, and working groups have been established.

High-Frequency Conductors, Cables, and Connectors. This subcommittee has been active in maintaining AIEE contact with developments within its scope. As a result of discussions at recent meetings of the subcommittee and of the Committee on Electronics, it has seemed desirable to expand the scope of this subcommittee somewhat, and the size of the group is being expanded and reinforced to handle its change of interest. It is expected that a technical session will be organized by the group in the near future.

Liaison with Nucleonics. This is a 1-man subcommittee, the objective of the activity being to maintain an adequate correlation with the work of the Committee on Nucleonics, and similar activities in other professional societies.

Electronic Aids to Navigation. This is a 1-man subcommittee whose function is to maintain adequate correlation with related work within the Committee on Communication, and with appropriate groups in the IRE.

Electronic Aids to Geophysics. This subcommittee, having to do with electronic equipment used in geophysical exploration primarily for the oil industry, is centered in the southwestern part of the United States. Its principal activity has had to do with the planning phases of a technical session sponsored by the Committee on Electronics at the 1950 Fall General Meeting.

Infrared Applications. This subcommittee has continued to study the specific problems of infrared instrumentation, nomenclature, and the broadening of the knowledge of infrared techniques among engineers. A set of definitions has been submitted through appropriate channels to the American Standards Association (ASA) and the American Society for Testing Materials (ASTM) committees on definitions of technical terms, and is being revised and supplemented for possible use as a committee report. A study was started to seek better testing and evaluation standards for photoconductive detectors used in infrared equipment. Liaison with the ASTM-ASA Committee on Nomenclature and Applied Spectroscopy has been continued with particular reference to infrared terminology.

Electronic Methods in Food and Biological Processing. This is a 1-man subcommittee whose responsibility has been to maintain active contact, particularly on the West Coast, with possible electronic methods for the objectives suggested by the title.

Magnetic Amplifiers. This subcommittee has been extremely active, particularly in the sponsorship of technical programs at the Summer and Pacific Meeting and the Winter General Meeting. The work-load of this committee and its importance has grown to a point where it has been made a technical committee of the Institute.

Electronic Applications of Semiconductor Devices. This subcommittee arranged a very successful technical conference as a part of the program of the Winter General Meeting. It has participated in joint standards planning with a similar group in the IRE. This subcommittee has also had an active part in the joint sponsorship, with the IRE, of the conferences on electron devices held in June 1950, and planned for June 1951.

Electronic Heating Liaison. This is a 1-man subcommittee charged with the responsibility of maintaining adequate contact with other groups within the AIEE active in the use of electronics for induction and dielectric heating. This subject matter is the primary responsibility of the Induction and Dielectric Heating Subcommittee of the Committee on Electric Heating. During the past year the AIEE contributions to this activity have included preparation of effective standards required to place this industry on a sound footing. The industry in general is using many of these standards, although they are still in subcommittee status. The

subcommittee's liaison has been very successful in keeping the main committee informed in regard to the substantial activities in this field by other committees of the AIEE, and associated groups within the IRE and NEMA.

Electronic Systems Engineering. One of the responsibilities of this subcommittee is to maintain an alert attitude toward making available to the AIEE membership material on electronic systems engineering that has its origin in military needs but which, at an appropriate time, can be declassified and presented to the professional societies. This subcommittee was responsible for the arrangement of a technical session held at the Fall General Meeting.

Electronic Circuit Components. This subcommittee was organized during the past year, its scope involving attention to preparation of standards and planning of technical programs relative to good engineering practice for quality electronic components (passive) including miniaturization. One of the reasons for the organization of this subcommittee was the great interest in passive components apparent at the quality electronic components conference in May 1950.

The following are the functional subcommittees.

Electronic Standards and Definitions. It is the responsibility of this subcommittee to maintain adequate orientation and stimulation among the other subcommittees regarding the general planning of standardization in the electronics field. This subcommittee has periodically presented to the committee as a whole reviews of standards problems in various areas of electronics.

Liaison with IRE. This is a 1-man subcommittee, the objective being to maintain a close contact in regard to policy matters of technical committee work with corresponding groups in the IRE.

Liaison with JETEC. The responsibility of this subcommittee is to maintain an active, informative contact with the Joint Electron Tube Engineering Council, particularly in relation to policy and planning objectives of the committee's work.

Education in Electronics. The objective of this subcommittee is to maintain a continuing review and cognizance of change and reorientation in matters of education in electronics, both in the universities and in the adult education field. This subcommittee periodically arranges conference programs at general meetings of the Institute, the last having been held during the Winter General Meeting. These sessions have been marked by very active discussion and a generally high level of audience participation in the program. The subcommittee also provides liaison with the Committee on Education.

Papers Review. The primary responsibility of this subcommittee is to handle matters connected with review of papers of the *Transactions* type. In addition, this group has organized conference-type meetings as part of general meetings of the Institute. Two such meetings, devoted to "New Electronic Devices," were held at the Winter General Meeting, and one on the general subject of "Research Administration in Electronics" is planned for the Summer General Meeting.

West Coast Subcommittee. This is a relatively informal but very active subcommittee, whose leadership during the past two years has been provided by the West Coast Vice-Chairman of the Committee on Electronics. This subcommittee accepted the entire responsibility for the organization and planning of three technical sessions held at the Summer and Pacific General Meeting. Particular attention was devoted in these sessions to problems in equipment for nuclear particle accelerators, in collaboration with the Committees on Nucleonics and on Electronic Power Converters, and to new instrumentation techniques in the electronics field. All of the meetings were very well attended, and there was active audience participation.

General. The activities in supporting technical and conference sessions at general meetings of the Institute during the past year total 15 full sessions, with four shared by other committees.

COMMITTEE ON INSTRUMENTS AND MEASUREMENTS

The activities of the committee have been quite varied and numerous. The western division of the committee was strengthened to provide adequately for an active instruments and measurements program in that area. Membership is equally divided among educational institutions, government and private laboratories, utilities, and manufacturers, and covers all major fields of instruments and measurements.

The committee has two vice-chairmen, one for the activities of the East and one for the activities of the West. In addition to having a general secretary located in the East, a secretary for the West was appointed to assist the western vice-chairman. The increase in the number of instruments and measurements *Transactions* papers and technical sessions of that area is a definite endorsement of this western expansion policy.

The first committee meeting of the year was held October 2, 1950, to formulate the plans for the coming year. A luncheon meeting was held during the Winter General Meeting. A third meeting was held April 4, 1951, at the National Bureau of Standards, to complete plans for forthcoming meetings and to discuss subcommittee reports. A luncheon and a tour of the Bureau followed the meeting.

Changes

Subcommittee on the Preparation of a Master Test Code for Temperature Measurements has been discontinued, since the Test Code AIEE *551* was issued August 15, 1950.

Subcommittee on Electrical Aids to Medicine, which was a Joint Subcommittee of the Committees on Instruments and Measurements, Electronics, and Therapeutics will become a main committee August 1, 1951. It will be called Committee on Electrical Techniques in Medicine and Biology, and will replace also the Committee on Therapeutics.

Subcommittee on a Master Test Code for Speed Measurements has been established at the request of the Test Code Coordinating Subcommittee of the Committee on Rotating Machinery.

Subcommittee on Recorders and Controllers has been created.

Subcommittee on Navigation Instruments has been formed.

Activities of Subcommittees

Subcommittee on Organization is investigating the existing structure of the main committee to determine the feasibility of reorganizing it in a manner somewhat similar to a Division.

Subcommittee on Revision of Standard Number 4, Measurement of Test Voltage in Dielectric Tests is preparing a revised draft of a proposed new standard.

Subcommittee on Watt-hour Meters has prepared a preliminary draft of a bibliography on watt-hour meters covering about 225 periodicals and book references.

Subcommittee on Definitions has been active in assisting in the preparation of the third draft of Group 30 definitions—instruments, meters, and meter testing—being prepared by Subcommittee Number 6 in ASA-*C42*.

Subcommittee on Electrical Tests on Dielectric Measurements has completed a report on a survey which it made to determine current practices in field testing of dielectrics; this report was presented at the Winter General Meeting and will be published in the near future. It sponsored a technical session on insulating oil testing at the Winter General Meeting.

Subcommittee on Recorders and Controllers, while still in the organizational stage, is planning a program for the Fall General Meeting.

Subcommittee on High-Frequency Measurements, acting jointly with the IRE Committee on High-Frequency Measurements, sponsored a very successful conference on high-frequency measurements in Washington, D. C., in January 1951.

Subcommittee on the Marking of Varmeters and Related Instruments completed a report on the results of the survey to determine the practices in marking varmeters. This report was published in *Electrical Engineering*, and was presented at the Winter General Meeting.

Subcommittee on Co-operation with the Instrument Society of America (ISA) sponsored two technical sessions at the ISA conference in Buffalo, N. Y., one on September 20 and the other on September 21, 1950. An AIEE-sponsored luncheon was held on September 21. The average attendance at these three affairs was approximately 65. The Niagara Frontier Section of the AIEE was of invaluable assistance in making the necessary local arrangements.

Subcommittee on a Master Test Code for Power Measurements has made a second draft of a proposed Master Test Code for Power Measurements. At present it is being reviewed by the subcommittee members.

Subcommittee on Industrial Spectroscopy has confined its activities to sponsoring

a technical session at the Winter General Meeting.

Subcommittee on a Master Test Code for Speed Measurements is preparing a preliminary draft of a proposed test code.

Subcommittee on Navigation Instruments is still in the organizational stage.

Activities of Joint Subcommittees

Joint Subcommittee on Instrument Transformers has been actively engaged in obtaining *Transactions* papers for various meetings.

Joint Subcommittee on Telemetering has continued active collaboration with the National Telemetering Forum (NTF). The subcommittee is still engaged in completing a glossary of telemetering terms which had been started by the Instrument Research Division of the National Advisory Committee for Aeronautics. The proceedings of the technical conference on telemetering, which conference was sponsored by this subcommittee and the NTF last May in Philadelphia, were edited by this subcommittee and issued early this year. A technical session is being planned for the Summer General Meeting.

Joint Subcommittee on Electronic Instruments is completing work on the specification formats for vacuum-tube voltmeters and for cathode-ray instruments. Similar specification formats for signal sources have been started. The Proceedings of the conference on improved quality electronic components, which conference was jointly sponsored by this subcommittee, the IRE, and Radio Manufacturers Association last May in Washington, D. C., were edited by this subcommittee and issued early this year. This subcommittee also sponsored a technical session at the Winter General Meeting.

Joint Subcommittee on Nucleonic Instruments, working in collaboration with the Joint Subcommittee on Electrical Aids to Medicine and the IRE, sponsored the third annual Joint AIEE-IRE conference on electronic instrumentation in nucleonics and medicine held in New York City last October. This subcommittee is assisting the Civil Defense Administration in the field of nuclear instruments, and has published an article in *Electrical Engineering* on the subject of "Suitable Instruments for Radiation Measurements." It is preparing a set of definitions, standards procedures, and test methods for the scintillation detector to parallel a similar set of definitions formulated by the IRE. It sponsored a technical session at the Winter General Meeting, and is arranging a session for the Summer General Meeting.

Other Activities. The Committee on Instruments and Measurements continued its activities in other fields through its contacts with other committees of the AIEE, the American Standards Association, and The American Society of Mechanical Engineers.

In addition to the previously mentioned eight sessions, the committee sponsored one session at the Middle Eastern District Meeting; part of one session at the Southern District Meeting; two sessions at the Winter General Meeting; one at the Great Lakes District Meeting; and has planned two sessions for the 1951 Summer General Meeting. This makes a total of 15 technical sessions on instruments and measurements for the 1950–51 season.

COMMITTEE ON MAGNETIC AMPLIFIERS

Magnetic amplifier work in the AIEE was organized as a subcommittee of the Committee on Electronics in the fall of 1948. In 2½ years it has grown to an Institute technical committee, operating with nine subcommittees, and has produced a progress report covering the initial work on definitions, standards, and application information. Through the committee discussions and the progress report on definitions and standards, much of the loose talk regarding magnetic-amplifier performance has been eliminated, and a majority of the papers and articles are now appearing with information presented in a mutually understandable form. This marks the end of one phase of the committee work. The activity is quite firmly established in the AIEE, and is providing the desired interchange of ideas and progress in standardization.

The principal subcommittees now having active assignments are those on Definition Ratings, Applications, Test Code, Materials, and Non-Linear Circuit Theory arising particularly in magnetic amplifiers. The committee is also sponsoring some bibliography work.

Definitions Subcommittee, having established the basic definitions, must now settle down to the task of providing mutually agreeable terms for many of the commonly used circuit arrangements and principles of operation, and has also been requested to start work on standardization of symbols, both graphical and literal.

Materials Subcommittee is expected, through conference sessions jointly sponsored with other groups, to bring out the vital importance of materials in magnetic amplifiers and to give a clear picture of the limitations and possibilities of the materials, and of their true relationship to obtainable magnetic amplifier performance from a fundamental viewpoint.

Ratings Subcommittee has a real job in working out necessary rating quantities and methods of expressing performance of this essentially nonlinear device. A good start has been made, and a rating can now be given to a magnetic amplifier based on the proposals in the progress report. These recommendations are being used by the principal suppliers. The next job for this group is concerned with rating and expression of the performance of the saturable reactor, which surprisingly appears to present more of a problem than the complete magnetic amplifier.

Test Code Subcommittee has started its work of finding agreed-upon methods of implementing the standards and definitions by generally feasible forms of test.

Application Subcommittee has been formalized recently, although a number of conference and technical papers have dealt with various applications. This subcommittee will continue to work largely in this way, although it may provide a beneficial service by a report showing the scope of application and the limit of performance that has been achieved in various lines such as frequency, sensitivity, freedom from temperature variations, linearity, speed, and the like. Also the number and variety of circuits and uses continue to increase at a tremendous rate, and a group keeping track of this activity will be of considerable benefit to the industry.

Subcommittee on Non-Linear Circuit Theory arose spontaneously within the committee because of a keen interest on the part of some of the members in working mutually on the advanced circuit analysis techniques involved in nonlinear circuits, particularly those of interest in this field.

In the military field, magnetic amplifiers are already an accepted necessity. A large number of naval specifications are now coming out requiring magnetic amplifiers without electronic tube substitutions permitted. In atomic power work, where reliability is paramount, there is a general swing to magnetic amplifiers for many kinds of applications including d-c power supplies and the various control system components. Many applications are being sought in aircraft, and one autopilot operation will use over a million dollars worth of magnetic amplifiers per year. Other applications in aircraft are heater controls, wing flap controls, and so forth.

The reason for applications vary considerably, and the magnetic amplifier is not dependent upon any one characteristic for its acceptance or choice in comparison with other methods. It actually can be built with lower losses, less heat dissipation, and to occupy smaller space than comparable electronic devices such as the power stage for handling small servo motors, and so forth. Thus, space and heat economy are the ruling characteristics in some applications. In others, the comparative shock-proofness is a requisite quality. In other applications, the reliability and long life predominate as the characteristics principally determining the choice of the magnetic amplifier over electronic or rotating devices.

The industrial control application of magnetic amplifiers brings in the cost factor more predominantly than any other field, particularly for the less important control. However, for the more important controls handling important processes or expensive machinery, there is no question about the justification for the magnetic amplifier. The principal deterrent is simply the time required to change over designs from current styles to those incorporating the magnetic amplifier. Already it has found its way into an imposing list of industrial applications including steel mill controls, reel drives of various kinds, motor controls, voltage and frequency regulators, speed regulators, volts per cycle regulators, elevator controls, aircraft controls, paper mill applications, and a host of others.

Its use as the equivalent of a d-c current transformer for heavy current d-c busses likewise has been accepted and is spreading.

There are many unsolved problems in the magnetic amplifier. It is a nonlinear circuit with many facets as yet uncovered. A recent bibliography of literature and patents covers 52 pages of references to technical work bearing on the magnetic amplifier and the associated iron and nonlinear circuit characteristics. Yet today new characteristics and possible performance

features are being discovered at a still increasing rate. When it is realized that only the simplest of the nonlinear circuits have been explored at all, and these not thoroughly, it is evident that the magnetic amplifier is only a small start on the application of nonlinear circuit devices involving saturation.

COMMITTEE ON METALLIC RECTIFIERS

A committee meeting was held during the Winter General Meeting, and the committee sponsored a session, which included several papers, at the Summer General Meeting.

Definitions and Test Code Subcommittees reported that standard definitions and test code were reviewed and additions were made to agree with requests for new definitions. A new edition was authorized by the committee.

Miniature Rectifiers Subcommittee. A preliminary report on methods of rating metallic rectifiers using capacitor loads was reviewed. The subcommittee is making a further study of the matter.

Patents Subcommittee. After reviewing the patent list, the committee decided that a new edition should be written.

Bibliography Subcommittee. The preparation of a new edition of the bibliography was authorized by the committee.

COMMITTEE ON NUCLEONICS

The committee has almost completed one of the tasks which it set at the time of its organization. It has reached a state where there seems to be little need for additional papers to bring to electrical engineers the basic concepts of nucleonics. The chief subjects of current interest are: nucleonic instruments, particularly those needed for routine measurement of radiation; isotopic tracers, particularly when used in industrial processes; and nuclear machines of various types, including particle accelerators. To deal with these, the subcommittee organization developed last year has been continued.

The committee was again one of the sponsors for the joint AIEE-IRE special technical conference on electronic instrumentation in nucleonics and medicine, which was held in New York October 23–25, 1950.

The committee assisted in obtaining two papers for the Great Lakes District Meeting, but has devoted its major effort toward two technical sessions at the Summer General Meeting. A particular effort is being made in this direction because of the opportunity it affords for bringing into the program Canadians working in nucleonic fields.

One annoying, although probably necessary, obstacle to be overcome in obtaining conference or technical papers is that resulting from the necessity of securing "clearance" from the appropriate government agencies. The time that this involves, when added to that necessary to comply with Institute procedures, is so great as to be serious. This is particularly true when there has been a change in subcommittee chairmanship, for the new incumbent requires at least two months to develop the broad outlines of the program for the year.

COMMITTEE ON THERAPEUTICS

The Committee on Therapeutics jointly sponsored a technical conference with the Electronics Subcommittee on X-Ray Tubes, Apparatus, and Applications at the Winter General Meeting. This was a conference relating to X-ray and electromedical applications of electrical engineering. Five papers were presented to about 50 attendants.

The Committee on Therapeutics and the Subcommittee on Electrical Aids to Medicine have jointly recommended combination of their activities into a single Committee on Electrical Techniques in Medicine and Biology. A recommended scope was prepared at the joint meeting of the two committees. The merger of the two committees, its name, and scope have been approved by the Board of Directors. It is believed that the union of these two existing committees into one will eliminate certain overlapping within their scopes and create a stronger committee, which will strengthen the Institute's position in the electromedical manufacturing industry, the application of some equipment, and co-operation between the Institute and the medical profession.

AWARDS

EDISON MEDAL

The Edison Medal for 1950 was awarded to Otto B. Blackwell (retired), American Telephone and Telegraph Company, "for his pioneer contributions to the art of telephone transmission," and was presented to him on January 24, 1951, during the Winter General Meeting.

The medal may be awarded annually for meritorious achievement in electrical science, electrical engineering, or the electrical arts. Awards are made by a committee of 24 members of the Institute.

LAMME MEDAL

The Lamme Medal for 1950 was awarded to Donald I. Bohn, Chief Electrical Engineer, Aluminum Company of America, "for his pioneering development and application of electrical equipment for controlling rectifying systems in the production of aluminum." The medal will be presented to him on June 25, 1951, during the Summer General Meeting.

The medal may be awarded annually by a committee of nine members to a member of the AIEE for "meritorious achievement in the development of electrical apparatus or machinery."

JOHN FRITZ MEDAL

The John Fritz Medal may be awarded annually for notable scientific or industrial achievements by a board of award composed of representatives of the American Society of Civil Engineers (ASCE), The American Society of Mechanical Engineers (ASME), American Institute of Mining and Metallurgical Engineers (AIME), and AIEE. The 1951 medal was awarded to Dr. Vannevar Bush, President of the Carnegie Institution of Washington, "for outstanding contributions to his country and to his fellow men."

The medal was presented, in absentia, January 23, 1951, during the Winter General Meeting.

HOOVER MEDAL

The Hoover Medal for 1950 was awarded to Dr. Karl T. Compton, Chairman of the Corporation of the Massachusetts Institute of Technology, with the following citation: "Great leader in engineering education, who had a profound influence on the development of science and engineering, and has devoted himself wholeheartedly to the welfare of the Nation, both in times of peace and in times of war." The medal was presented to him on January 22, 1951, during the Winter General Meeting.

The Hoover Medal is awarded by a board representing the ASCE, AIME, ASME, and AIEE "for outstanding civic or humanitarian activities constituting distinguished public service."

MARSTON MEDAL BOARD OF AWARD

This medal is presented annually at the commencement exercises of Iowa State College to a graduate of that institution who has achieved success in his field of engineering activity.

The award for the year 1950 was made to C. E. Prudden, a graduate in mechanical engineering, who served Allis-Chalmers Manufacturing Company as Chief Engineer of its Tractor Division, and is now President of the Society of Automotive Engineers.

CHARLES LeGEYT FORTESCUE FELLOWSHIP COMMITTEE

The availability of this award was brought to the attention of all departments of electrical engineering in the country that offer accredited programs. Financial statements were reviewed by the committee members, and it was decided to grant one $1,500 fellowship for the year 1951–52. A total of 11 applications for the award was received. All applicants appeared to be well qualified.

The recipient of the award for the coming year is Mr. Clarence J. Baldwin of the University of Texas. In addition to his outstanding scholastic attainments, Mr. Baldwin has demonstrated exceptional leadership in university student affairs. He will continue his studies at the University of Texas.

ALFRED NOBLE PRIZE

The Alfred Noble Prize for the year ending June 1, 1950, was awarded to Ralph J. Kochenburger, Associate AIEE, for his paper, "A Frequency Response Method for Analyzing and Synthesizing Contactor Servomechanisms." The ceremony was held at the Winter General Meeting in New York on January 2, 1951. The prize is a cash award of $350, accompanied by a certificate signed by the President and Secretary of the American Society of Civil Engineers (which Society has been designated as Trustee of the Fund), and bears the names of the respective societies participating in the award.

The prize was established in 1929 and is awarded to a member of any grade of the ASCE, AIME, ASME, AIEE, or the Western Society of Engineers for a technical paper of exceptional merit presented before one of the societies and published in their technical publications, provided the author has not passed his 31st birthday at the time the paper is submitted.

The recipient of the prize is selected by a committee of five consisting of one representative of each society. The report of the committee is made to the Board of Direction

of the ASCE on or before November 1. The presentation is made publicly at a general meeting of the society, of which the recipient is a member, by a representative of the ASCE.

JOINT ACTIVITIES

UNITED ENGINEERING TRUSTEES, INC.

For the four Founder Societies, the United Engineering Trustees, Inc., administers the funds and property in the Engineering Societies Building, the Engineering Societies Library, and the Engineering Foundation. It also serves as Treasurer of the Engineers' Council for Professional Development.

Efforts have been in progress for several years to find ways and means to secure an adequate building for an engineering center which would carry out Andrew Carnegie's ideals.

ENGINEERING FOUNDATION

The Engineering Foundation is a department of the United Engineering Trustees, Inc., and its general objective is "the furtherance of research in science and engineering."

With the income from its endowment funds, it supports a broad range of research projects, now numbering about 14. Some of its most effective contributions are those supporting studies and analyses necessary in the early stages of organizing projects on such bases that financial support from other sources becomes available. During the year 1949–50, the share of the Foundation in the cost of researches sponsored by it was a little less than three per cent.

ENGINEERING SOCIETIES LIBRARY

The library is a department of the United Engineering Trustees, Inc., and was formed by combining the separate libraries of the ASCE, AIME, ASME, and AIEE, and is conducted as a free public reference library.

In addition to affording the use of a large collection of engineering books and periodicals, the library renders special services such as bibliographies, translations, photostats, searches, and book loans by mail.

A revised Library Agreement has been approved by the Library Board, the United Engineering Trustees, Inc., and the Boards of the Founder Societies. In it, the ownership and title to books, documents, equipment, and other property in the custody of the Library are vested in the United Engineering Trustees, Inc., unless specifically prohibited by the original deeds of gift or bequests.

In order to conserve space, the Library is studying more critically new material received, and is discarding little-used material in larger amounts than ever before.

COMMITTEE ON ENGINEERING SOCIETIES MONOGRAPHS

One book was published: "Theory of Flow and Fracture of Solids," volume 1, by A. Nadal. Two books have been accepted and are in process of publication: "The Buckling Strength of Metal Structures," by F. Bleich, and "The Theory of Elasticity," by S. Timoshenko. One manuscript on "Hydraulics Transients" is now under review. Three manuscripts were submitted, but not accepted.

The committee is composed of two representatives each of the ASCE, AIME, ASME, and AIEE. The royalties from the books published are paid to the Engineering Societies Library.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

The principal activities of ECPD include programs for the guidance of young persons thinking of entering the engineering field, the accrediting of curricula of engineering schools, and encouragement and assistance to individuals in their engineering and cultural studies during several years following graduation. The council represents ASCE, AIME, ASME, AIEE, The American Institute of Chemical Engineers (AIChE), the Engineering Institute of Canada, the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners.

ECPD approved and referred to the constituent societies the report of the Committee on Professional Recognition recommending the adoption of uniform grades of membership. The AIEE Board of Directors approved the uniform grades, and submitted to the membership proposed Constitutional amendments including them.

Revisions in the Charter of ECPD were submitted to and approved by the constituent societies.

ENGINEERS JOINT COUNCIL

The membership of this council includes the two most recent available past Presidents and the Secretaries, also the Presidents as ex officio members without votes, of the five societies ASCE, AIME, ASME, AIEE, and AIChE. Its principal functions are to study matters of mutual interest to the member societies, recommend joint action when desirable, and administer activities upon approval of a majority of the societies.

During the past year, the Engineering Manpower Commission was organized to aid in the establishment of policies for the most effective utilization of engineers in the national effort; a survey of selected engineering personnel for the Department of Defense was completed and definitions of 253 fields of specialization, in which 63,689 engineers of high standing listed themselves, were prepared; and the Water Policy Panel submitted a comprehensive report.

The Exploratory Group to Consider Further Unity in the Engineering Profession, which was organized at the invitation of EJC, submitted a report which is being studied by the societies.

Many other matters were considered during the year.

JOINT AIEE-IRE CO-ORDINATION COMMITTEE

The Joint AIEE-IRE Co-ordination Committee was established by the Boards of Directors of the AIEE and the IRE. The first meeting of the committee was held September 5, 1950.

By the establishment of this Joint Co-ordination Committee, opportunity is provided to discuss subjects of mutual interest and to recommend action thereon.

Recommendation was made that a continuing joint subcommittee be established, under the Education Committee of the IRE and the Committee on Student Branches of the AIEE, to resolve differences which occur in the operation of Joint Student Branches. This recommendation was approved by the respective Boards of Directors, and members of the subcommittee have been appointed.

INTER-SOCIETY CORROSION COMMITTEE

The Inter-Society Corrosion Committee, fostered by the National Association of Corrosion Engineers, was established in 1949, and held its third annual meeting in New York in March 1951. The committee membership now comprises delegates from 30 United States and Canadian engineering and scientific associations and government agencies having an interest in corrosion and its prevention.

During the past year by-laws of the committee were adopted by vote of the societies represented upon it through delegate members. At the meeting in March, a subcommittee reported upon the activities in the field of corrosion of societies represented upon the committee, and further reports of a similar character from delegate members were received. Other subcommittees previously appointed and at work during the past year are those on Standard Definitions and Terminology and on Liaison with Foreign Laboratories and Corrosion Agencies.

In furtherance of one of the main objectives of the committee, namely, the promotion of co-operation and the avoidance of undue duplication of effort, the AIEE delegates to the Inter-Society Corrosion Committee have been in contact during the past year with AIEE committees whose fields of interest were thought to include corrosion in a major or minor degree. In about half of these cases, interest and the desire to be kept further informed were manifested.

REPRESENTATIVES

The Institute is represented in many other joint activities not covered by this report, and a complete list may be found in the Year Book, or in the September issue of *Electrical Engineering*.

APPRECIATION

The continuing rapid increase in membership and expansion in technical activities reflect great credit upon the general and technical committees and the District, Section, and Student Branch officers and committees. The Board of Directors extends to all of these groups and to the membership in general its heartiest congratulations and thanks.

Respectfully submitted for the Board of Directors.

H. H. HENLINE
Secretary

HASKINS & SELLS
CERTIFIED PUBLIC ACCOUNTANTS

250 PARK AVENUE
NEW YORK 17

ACCOUNTANTS' CERTIFICATE

American Institute of Electrical Engineers:

We have examined the balance sheet of American Institute of Electrical Engineers, and schedule of securities owned, as of April 30, 1951, and the related statements of income and operating fund reserve and of restricted fund reserves for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet, schedule of securities owned, and statements of income and operating fund reserve and of restricted fund reserves present fairly the financial position of, and securities owned by, the Institute at April 30, 1951, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) HASKINS & SELLS

New York,
May 18, 1951

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Exhibit A — **Balance Sheet, April 30, 1951**

ASSETS			LIABILITIES	
Property Fund Assets:			**Property Fund Reserve**	$ 529,056.67
One-fourth interest in physical properties of United Engineering Trustees, Inc.:				
Land, buildings, and equipment (less depreciation and renewal reserve)	$306,752.07			
Funded depreciation and renewal reserve	191,696.41			
Total	$498,448.48			
Equipment:				
Library (nominal value)	1.00			
Office furniture and fixtures (less reserve for depreciation, $35,335.34)	27,605.84			
Works of art, etc.	3,001.35			
Total property fund assets		$ 529,056.67		
Restricted Fund Assets:			**Restricted Fund Reserves** (Exhibit C):	
Securities—at cost (quoted market value, $694,582.00)—Schedule 1	$584,660.72		Reserve capital fund	$548,767.87
Cash (including $1,760.83 Canadian funds):			Life membership fund	7,357.51
Reserve capital fund	6,760.09		Member-for-Life fund	12,719.21
Life membership fund	2,314.81		International Electrical Congress of St. Louis Library fund	6,608.69
Member-for-Life fund	2,857.76		Lamme Medal fund	4,440.44
International Electrical Congress of St. Louis Library fund	1,565.99		Mailloux fund	1,023.44
Lamme Medal fund	160.00		Volta Memorial fund	19,438.17
Mailloux fund	1,023.44		Retired employees insurance fund	2,000.00
Volta Memorial fund	734.01			
Retired employees insurance fund	2,000.00			
Accrued interest receivable	278.51			
Total restricted fund assets		602,355.33	Total restricted fund reserves	602,355.33
Operating Fund Assets:			**Operating Fund Reserve, Liabilities, Etc.:**	
Cash (not including $2,225.01 for Federal taxes withheld from employees)	$ 6,048.32		Accounts payable	$ 26,512.75
Accounts receivable:			Deferred income:	
Members—for dues (less reserve, $7,700.00)	15,589.22		Dues received in advance	4,719.56
Advertisers	2,966.30		Entrance fees and dues advanced by applicants for membership	2,884.15
Miscellaneous	4,574.47		Subscriptions to publications received in advance	22,657.30
Accrued interest receivable	2,209.27		Miscellaneous (including unallocated receipts)	1,346.27
Inventories:			Operating fund reserve (Exhibit B)	17,231.51
Transactions, etc.	2,306.00			
Text and cover paper	13,904.90			
Badges	9,204.64			
Deferred charges:				
Production charges for May issue of *Electrical Engineering*	17,578.42			
Travel advances	970.00			
Total operating fund assets		75,351.54	Total operating fund reserve, liabilities, etc.	75,351.54
Total		$1,206,763.54	**Total**	$1,206,763.54

Note: On October 26, 1950, the Board of Directors transferred title to the Institute's books, papers, and so forth, except as to restricted gifts, to United Engineering Trustees, Inc.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Exhibit B — **Statement of Income and Operating Fund Reserve for the Year Ended April 30, 1951**

Income:		
Dues (including $207,684.00 allocated to *Electrical Engineering* subscriptions)		$457,552.94
Advertising in *Electrical Engineering*		202,136.40
Transactions subscriptions		18,608.45
Electrical Engineering subscriptions		33,914.81
Miscellaneous publications (preprints, Standards, and other publications)		53,462.44
Students' fees		35,254.00
Entrance fees		18,432.27
Registration fees—Institute meetings and technical conferences		19,812.62
Membership badges		4,694.90
Transfer fees		3,780.00
Interest and dividends on investments of Reserve Capital Fund		27,594.91
Total income		$875,243.74
Expenses:		
Publications expense:		
Electrical Engineering text	$191,064.15	
Electrical Engineering advertising	102,203.87	$293,268.02
Transactions		30,546.65
Proceedings		38,298.92
"Year Book"		15,884.32
Miscellaneous publications (preprints, Standards, and other publications)		38,446.92
Institute meetings		31,346.53
Institute Sections		98,522.49
Institute Branches, including paper prizes, etc.		8,939.18
Finance Committee		850.00
Headquarters Committee (including $925 wiring costs—air conditioning)		1,382.46
Membership Committee		24,688.87
Transfers Committee		87.67
Standards Committee		16,654.34
Technical Committees		15,594.06
Committee on Public Relations		7,219.18
Constitution and By-Laws Committee		3,183.06
Edison Medal Committee		266.35
Lamme Medal Committee		114.30
Forward	$625,293.32	$875,243.74
Total Income (forward)		$875,243.74
Expenses (forward)	$625,293.32	
Traveling expenses:		
Geographical Districts:		
Executive Committees	7,732.45	
Vice-Presidents	1,867.90	
Conferences on student activities	10,040.99	
Board of Directors	20,274.25	
Nominating Committee	1,909.50	
President's appropriation	970.62	
Institute representatives	116.32	
Administrative expenses	106,335.00	
Geographical Districts—Branch paper prizes	745.65	
Institute prizes	745.41	
Retirement system AIEE—normal contribution	9,342.45	
American Standards Association	1,500.00	
Canadian Radio Technical Planning Board	10.00	
Engineers' Council for Professional Development	2,163.20	
Engineering Foundation Project—Welding Research	250.00	
Engineers Joint Council	4,916.32	
Hoover Medal	292.43	
John Fritz Medal	181.68	
National Council of State Boards of Engineering Examiners	500.00	
United States National Committee—International Commission on Illumination	300.00	
National Fire Protection Association	100.00	
United Engineering Trustees, Inc.:		
Building assessments	19,803.64	
Library assessments	15,498.35	
Library retirement plan	3,499.45	
Membership badges	4,618.65	
Legal services	250.00	
Rent, etc.—Editorial office, 500 Fifth Avenue	7,007.54	
Exchange allowances	9,574.02	
Provision for doubtful accounts	9,079.95	
Transfer to Property Fund Reserve for furniture and fixtures expenditures	5,150.89	
Total expenses	$870,069.96	
Less—Expenditures for air-conditioning equipment for the two years ended April 30, 1951, originally charged to Operating Fund Reserve, now treated as repayment of loan from Capital Fund Reserve (see below)	10,572.68	
Total expenses (net)		859,497.28
Excess of Income over Expenses for the Year		$ 15,746.46
Operating Fund Reserve, May 1, 1950		12,057.73
Total		$ 27,804.19
Less—Repayment of advances from Reserve Capital Fund (see above)		10,572.68
Operating Fund Reserve, April 30, 1951		$ 17,231.51

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Exhibit C — **Statement of Restricted Fund Reserves for the Year Ended April 30, 1951**

	Total	Reserve Capital Fund	Member-for-Life Fund	Life Membership Fund	International Electrical Congress of St. Louis Library Fund	Lamme Medal Fund	Mailloux Fund	Volta Memorial Fund	Retired Employees Insurance Fund
Balance, May 1, 1950	$595,145.26	$543,295.65	$11,288.94	$7,610.88	$6,382.33	$4,440.44	$1,021.38	$19,105.64	$2,000.00
Additions:									
Income from bonds	$ 983.82		$ 126.90	$ 138.39	$ 138.53	$ 160.00		$ 420.00	
Interest on bank balances	65.70			45.54			$ 20.16		
Operating fund loan repayments: 1949-1950 (leaving a balance of $19,427.32 due from Operating Fund)	10,572.68	$ 10,572.68							
Allocated portion of dues	2,292.00		2,292.00						
Profit on sale of securities, etc.	5,912.12	5,472.22		213.47	226.43				
Total additions	$ 19,826.32	$ 16,044.90	$ 2,418.90	$ 397.40	$ 364.96	$ 160.00	$ 20.16	$ 420.00	
Total	$614,971.58	$559,340.55	$13,707.84	$8,008.28	$6,747.29	$4,600.44	$1,041.54	$19,525.64	$2,000.00
Deductions:									
Expenditures for air-conditioning equipment made by Operating Fund for account of Reserve Capital Fund	$ 10,572.68	$ 10,572.68							
Authorized withdrawal from life membership fund	650.77			$ 650.77					
Purchase of medal, cost of engraving, etc. (exclusive of $114.30 paid from operating fund)	160.00					$ 160.00			
Library purchases	156.70				$ 138.60		$ 18.10		
Traveling expenses—District Branch prize winners	988.63		$ 988.63						
Costs of printing applications, etc.	87.47							$ 87.47	
Total deductions	$ 12,616.25	$ 10,572.68	$ 988.63	$ 650.77	$ 138.60	$ 160.00	$ 18.10	$ 87.47	
Balance, April 30, 1951 (Exhibit A)	$602,355.33	$548,767.87	$12,719.21	$7,357.51	$6,608.69	$4,440.44	$1,023.44	$19,438.17	$2,000.00

Schedule 1

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
Securities Owned, April 30, 1951

	Principal Amount of Bonds or Number of Shares of Stock	Restricted Funds						Total
		Reserve Capital Fund	Life Membership Fund	Member-for-Life Fund	International Electrical Congress of St. Louis Library Fund	Lamme Medal Fund	Volta Memorial Fund	
Railroad Bonds:								
Atlantic Coast Line first consolidated 4%, due 1952	$ 4,000.00					$4,253.78		$ 4,253.78
Baltimore & Ohio, Pittsburgh, Lake Erie & West Virginia System refunding 4%, due 1980	10,000.00	$ 6,450.00						6,450.00
New York Central Railroad Company 4% series A consolidated mortgage, due 1998	15,000.00	9,812.50						9,812.50
Northern Pacific Railway Company 4½% collateral trust, due 1975	15,000.00	15,307.50						15,307.50
Total railroad bonds		$ 31,570.00				$4,253.78		$ 35,823.78
Public Utility Bonds:								
American Telephone & Telegraph Company 2¾% debentures, due 1971	$ 5,000.00			$4,775.00				$ 4,775.00
American Telephone & Telegraph Company 2¾% debentures, due 1975	20,000.00	$ 10,062.50	$5,031.25		$5,031.25			20,125.00
Philadelphia Electric Company first refunding 2¾% due 1967	10,000.00	10,325.00						10,325.00
Total public utility bonds		$ 20,387.50	$5,031.25	$4,775.00	$5,031.25			$ 35,225.00
Industrial Bonds:								
Shell Union Oil Company 2¼% debentures, due 1971	$20,000.00	$ 19,800.00						$ 19,800.00
Standard Oil Company of New Jersey 2¾% debentures, due 1971	20,000.00	19,675.00						19,675.00
Total industrial bonds		$ 39,475.00						$ 39,475.00
United States Government Bonds:								
Treasury bonds 3%, due September 15, 1955/51	$ 2,000.00						$ 2,081.66	$ 2,081.66
Defense bonds series G 2½%, due December 1, 1954	18,000.00	$ 13,000.00		$5,000.00				18,000.00
Treasury savings bonds series G 2½%, due September 1, 1955	40,000.00	40,000.00						40,000.00
Treasury savings bonds series G 2½%, due November 1, 1956	17,000.00	17,000.00						17,000.00
Treasury savings bonds series G 2½%, due May 1, 1957	20,000.00	20,000.00						20,000.00
Treasury savings bonds series G 2½%, due October 1, 1957	30,000.00	30,000.00						30,000.00
Treasury savings bonds series G 2½%, due May 1, 1961	30,000.00	30,000.00						30,000.00
Treasury savings bonds series G 2½%, due July 1, 1961	15,000.00	15,000.00						15,000.00
Treasury bonds 2½%, due December 15, 1962/59	16,000.00						16,480.00	16,480.00
Total United States Government bonds		$165,000.00		$5,000.00			$18,561.66	$188,561.66
Total bonds		$256,432.50	$5,031.25	$9,775.00	$5,031.25	$4,253.78	$18,561.66	$299,085.44
Capital Stocks:								
Preferred Stocks:								
Atchison, Topeka & Santa Fe Railway Company	200 shares	$ 19,174.71						$ 19,174.71
Dow Chemical $4 cumulative, series A	100 shares	11,547.50						11,547.50
General Motors Corporation $5	200 shares	25,820.00						25,820.00
Ohio Edison Company 4.40%	200 shares	21,279.25						21,279.25
Scoville Manufacturing Company 3.65% cumulative	100 shares	10,111.25						10,111.25
United States Steel Corporation 7% cumulative	100 shares	14,885.00						14,885.00
Total preferred stocks		$102,817.71						$102,817.71
Common Stocks:								
American Can Company	60 shares	$ 4,988.40						$ 4,988.40
American Gas & Electric Company	400 shares	15,069.04						15,069.04
Caterpillar Tractor Company	200 shares	9,361.30						9,361.30
Consolidated Natural Gas Company	100 shares	4,428.80						4,428.80
Eastman Kodak Company	330 shares	9,699.90						9,699.90
E. I. du Pont de Nemours & Company	300 shares	12,278.14						12,278.14
General Electric Company	200 shares	7,748.66						7,748.66
General Motors Corporation	200 shares	4,235.53						4,235.53
Gulf Oil Corporation	200 shares	12,264.20						12,264.20
Insurance Company of North America	120 shares	10,847.50						10,847.50
International Harvester Company	300 shares	5,030.50						5,030.50
International Paper Company	200 shares	9,186.12						9,186.12
Louisville & Nashville Railroad Company	100 shares	6,278.13						6,278.13
Pacific Gas and Electric Company	200 shares	8,316.23						8,316.23
Public Service Electric and Gas Company $1.40 dividend preference common stock	300 shares	9,040.55						9,040.55
Sears, Roebuck and Co.	400 shares	6,014.97						6,014.97
Socony Vacuum Oil Company	400 shares	8,216.87						8,216.87
Standard Oil Company of Indiana	200 shares	8,170.32						8,170.32
Standard Oil Company of New Jersey	252 shares	12,219.99						12,219.99
Swedish Match Company class B	18 shares	100.00						100.00
Union Carbide & Carbon Corporation	300 shares	7,277.42						7,277.42
United Fruit Company	300 shares	11,985.00						11,985.00
Total common stocks		$182,757.57						$182,757.57
Total capital stocks		$285,575.28						$285,575.28
Total		$542,007.78	$5,031.25	$9,775.00	$5,031.25	$4,253.78	$18,561.66	$584,660.72

OF CURRENT INTEREST

Tiny Junction-Type Germanium Transistor Achieves Nearly Ideal Efficiencies

Significant advances in the development of the transistor,[1] the tiny amplifying crystal, have led to the construction of the "junction transistor,"[2-4] a new device with properties never before achieved in any amplifier. Like the original transistor, it is based on the semiconducting properties of germanium, and requires no vacuum, no glass envelope, and no heating element to cause warmup delay. It consists of a tiny rod-shaped germanium crystal treated so that it embodies a thin electrically positive layer sandwiched between two electrically negative ends.

The result of complex theoretical studies carried on by its inventor, Dr. William Shockley of the Bell Telephone Laboratories, as a part of the Laboratories' investigations of transistor physics, the tiny transistor is about half the size of a pea and consumes much less power than previous transistors, which themselves are far more efficient than vacuum tubes. It derives its name from the two "junctions" between the negative ends and the positive layer. A hard plastic bead about $^3/_{16}$ inch in diameter encases the transistor, and wire leads connect to each of the three regions and extend outside. It occupies about $^1/_{400}$ of a cubic inch, as compared to about $^1/_8$ cubic inch required by a typical subminiature vacuum tube.

The most remarkable feature of this transistor is its ability to operate with exceedingly small power consumption. An audio-frequency oscillator, for example, requires only 6 microamperes at 0.1 volt. This amounts to 0.6 microwatt of power, contrasted with the 1 watt or more needed to heat the cathode of an ordinary receiving-type vacuum tube.

Power handling capacity and efficiency, on the other hand, are high. The design is varied readily to permit a power dissipation of as much as 2 watts. Static characteristics are so nearly ideal that class *A* amplifier efficiencies of 48 or 49 per cent out of a possible 50 per cent can be realized, and the class *B* and class *C* efficiencies are correspondingly high.

Besides having nearly ideal efficiency, the junction-type transistor is extremely compact and rugged. Pigtail leads are brought out from the electrical connections to the germanium through the plastic shell to provide a sturdy and practically shockproof construction. Vibration tests in the audio-frequency range indicate relative freedom from microphonics.

The thin positive-type layer of germanium, which may be less than a thousandth of an inch thick, serves as base for the transistor; while the two negative-type ends serve as collector and emitter. If the collector is at a constant positive voltage with respect to the base, and a negative current is forced into the emitter (with battery and series resistor), the collector current is varied by varying the emitter current. In this case collector and emitter currents will be about equal, ranging from about 20 microamperes to as much as 5 milliamperes. Power output requirements will determine the exact amount of current that is required.

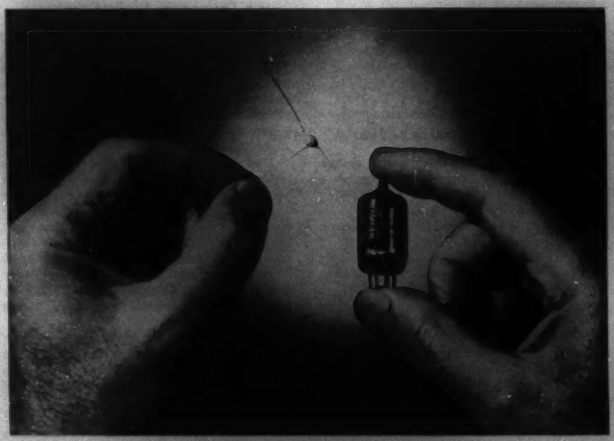
If the collector current is held constant, the changes in collector voltage will be extremely large for minute changes in emitter voltage, with voltage gains in the order of 10,000 times attainable.

For small-signal a-c operation, very low voltages are sufficient to produce useful gain. For operating in the micropower range, for example, the collector voltage need be only slightly over 0.1 volt and the collector current only about 20 microamperes. The power required to bias the collector into its useful range is then only a few microwatts. The total power used to operate the transistor is therefore only in the order of several microwatts.

The versatility of this transistor is another of its remarkable features. When connected with its base grounded, it will work between a low-impedance source (about 100 ohms) and a high-impedance load (1 megohm or more). Although the current gain will be less than unity, power gains as high as 40 to 50 decibels are possible and voltage gains may be extremely high.

For some circuits it is desirable to use the emitter as the grounded element, in which case gains of 50 decibels are possible. The input impedance will be a few hundred ohms, but the output impedance is a few hundred thousand ohms. With this connection there is both voltage and current gain. If the collector is used as the grounded element, the power gain drops far below that of the other two connections, but it is possible to obtain either very low output impedance or very high input impedance. If the signal voltage source is a few thousand ohms, the output impedance will be as little as 25 ohms or less. On the other hand, a large load impedance will make the input impedance to the transistor as high as several megohms.

This junction-type transistor has a rela-



The spidery object is the tiny new transistor invented at the Bell Telephone Laboratories. Among its unique properties is its ability to operate at nearly theoretically ideal efficiency and with extremely high voltage gains. The standard type 6AK5 miniature tube gives an idea of the transistor's size

Future Meetings of Other Societies

American Electroplaters' Society. July 30–August 2, 1951, Statler Hotel, Buffalo, N. Y.

Compressed Air and Gas Institute. September 20–21, 1951, Skytop Lodge, Skytop, Pa.

Hydraulic Institute. September 5–7, 1951, The Drake Hotel, Chicago, Ill.

Illuminating Engineering Society. National Technical Conference. August 27–30, 1951, Hotel Shoreham, Washington, D. C.

Institute of Radio Engineers. Western Convention and Seventh Annual Pacific Electronic Exhibit. August 22–24, 1951, Civic Auditorium, San Francisco, Calif.

Instrument Society of America. Sixth National Instrument Conference and Exhibit. September 10–14, 1951, Sam Houston Coliseum, Houston, Tex.

National Electronics Conference. October 22–24, 1951, Edgewater Beach Hotel, Chicago, Ill.

National Standardization Conference. 2nd Annual Conference. October 22–24, 1951, Waldorf-Astoria Hotel, New York, N. Y.

The American Society of Mechanical Engineers. Fall Meeting. September 25–28, 1951, Hotel Radisson, Minneapolis, Minn.

tively low noise figure, ranging between 10 and 20 decibels in most units measured (as compared with 50 decibels for earlier transistors). Its frequency response at full gain for the present is limited by the collector capacitance to a few kilocycles; but by using a suitable impedance mismatch, it is possible to get a frequency response that is flat up to at least 1 megacycle with a useful amount of gain.

Besides the junction transistor, the development program at the Bell Telephone Laboratories has led to vast improvements in the original transistor. This device, known as the "point contact" transistor, consists essentially of two hair-thin wires resting on a tiny speck of germanium. The recent refinements in this unit have been so successful that they now can be made as uniform in performance as vacuum tubes, and trial use in the Bell System is now being planned. Previously transistors were highly variable in characteristics and their reliability was uncertain.

Now that problems of reliability and reproducibility are understood, it is expected that regular production will begin. These transistors will withstand shock and vibration better than any known vacuum tube, and they are expected to have considerably longer service life than commercial vacuum tubes presently in use. The transistor can be designed for a great many special functions, so that its range of performance now includes a wide variety of applications which at present use commercial vacuum tubes.

REFERENCES

1. **Transistors, J. A. Becker.** *Electrical Engineering*, volume 69, number 1, January 1950, pages 58–64.

2. Some Circuit Properties and Applications of *n-p-n* Transistors, R. L. Wallace, Jr., W. J. Pietenpol. *Bell System Technical Journal* (New York, N. Y.), volume 30, number 3, July 1951, pages 530–563.

3. Some Circuit Properties and Applications of *n-p-n* Transistors, R. L. Wallace, Jr., W. J. Pietenpol. *Proceedings*, Institute of Radio Engineers (New York, N. Y.), volume 39, number 7, July 1951, pages 753–67.

4. *n-p-n* Transistors, W. Shockley, M. Sparks, G. K. Teal. *Physical Review*, American Institute of Physics (New York, N. Y.), volume 83, number 1, July 1951, pages 151–62.

Electric Monitoring System Keeps Trolleys on Schedule

A unique electric monitoring system enables one man to know the whereabouts of every streetcar and trolley coach along the 600 miles of track and road serviced by the Philadelphia Transportation Company, Philadelphia, Pa.

Using the monitoring equipment, a single dispatcher at headquarters can help to keep the firm's hundreds of electric vehicles on time. Nucleus of the system is a battery of 130 remote-control time switches and a 2-way radio control, both developed by the General Electric Company.

Complaints about delays in service have been reduced by more than 50 per cent since the system was installed. More than 2,500,000 passengers are transported daily by the company and approximately 200 delays are handled every day through the monitoring network.

Aided by the remote-control time switches, the dispatcher can determine the headways between streetcars or trolley coaches at

A clerk in the Philadelphia Transportation Company's control room watches the clocks maintained by the company's new monitoring system. Information is recorded from 130 time switches, which follow the progress of trolleys and trackless coaches owned by the company

recorder locations along the lines. When normal distances are not kept between vehicles, warning lights and a bell signal a warning to him. Thus alerted by electric devices, he can notify one of a force of 42 mobile troubleshooters via radio to investigate and clear up the delay.

Prior to this, delays could not be detected at once. Telephone reports had to be made to field offices before an investigator could be dispatched to the trouble-spot.

AIEE Fellow Honored by the Duquesne Light Company

In honor of, and as a perpetual testimonial to, Edmund William Oesterreich (A '21, M '25, F '42), two scholarships have been established at Carnegie Institute of Technology by Duquesne Light Company, Pittsburgh, Pa. Mr. Oesterreich is general superintendent of distribution of Duquesne Light Company.

Two part-tuition freshmen scholarships in the amount of $300 each are to be given to sons or daughters of Duquesne Light Company employees each year from the income derived from $17,500 that was given to the Carnegie Institute of Technology Endowment Fund in 1945, $12,500 of such amount having been given by Duquesne Light Company, and $5,000 by Philadelphia Company, Duquesne's parent company.

The scholarships are in recognition of the valuable contribution that Mr. Oesterreich has made to the saving of human life by his origination of the Oesterreich Method of Pole Top Resuscitation.

The Oesterreich method is a proved method of applying resuscitative measures on a pole top to persons electrically shocked into unconsciousness while working thereon. It permits immediate life-saving action in contrast with the former practice of waiting until the unconscious person could be lowered to the ground for the application of the Schafer prone pressure method. The consequent reduction in the time lapse between the shock and the start of the resuscitative measures has resulted in the saving of many persons who would otherwise have died.

Responsibility for the selection of those to whom the E. W. Oesterreich Scholarship awards are to be given is to rest with Carnegie Institute of Technology in accordance with established scholarship selection standards and the procedure of admission to Carnegie. The financial need of candidates should be considered only in the event that the aggregate of all other considerations is considered to be equal as between two or more candidates for an award.

The scholarships are not related to the company or its operations. No summer employment will be offered or required. There will be no obligation on the part of the company or the recipients of E. W. Oesterreich Scholarships regarding employment after graduation. The company assumes no obligation with respect to the orientation of students, counseling, or special instruction.

Palisades Dam and Power Plant Approved as Defense Project

Recommendations by the Defense Electric Power Administration have been approved for expeditious construction by the Bureau of Reclamation of Palisades Dam and power plant on the main stem of the Snake River at Calamity Point, in eastern Idaho. Construction will commence as soon as funds are available.

The big multiple-purpose reclamation project will provide additional irrigation water for 650,000 acres of Upper Snake River Valley farm lands, for which water supplies are now inadequate. Also, it is urgently needed to help meet growing defense electric power loads in the Pacific Northwest.

The power plant will have an installed capacity of 112,500 kw and, in a median water year, will produce approximately 500,000,000 kilowatt-hours of electric energy. The project has already been authorized by the Congress and some $3,000,000 has been spent on preconstruction work.

Palisades is a multiple-purpose reclamation project, including irrigation, power, flood control, recreation, and fish and wildlife benefits. The reservoir will have a total active storage capacity of 1,200,000 acre-feet. Estimated cost is $76,601,000.

New Industrial X-Ray Process Developed by Joint Program

Commercial development of xeroradiography, a new process that may greatly reduce the use of films and darkrooms in industrial X-ray work, is the object of a joint program launched recently by three organizations: the Haloid Company of Rochester, New York; Battelle Memorial Institute, Columbus, Ohio; and General Electric X-Ray Corporation, Milwaukee, Wis. (See *Electrical Engineering*, January 1949, page 46.)

Xeroradiography is expected to make X-ray inspection faster and more economical so that it can be utilized in many more industrial fields for the first time, particularly in smaller foundries, machine shops, general metal-working firms, and many other types of plants. It also may provide a tool of considerable value in the inspection of ordnance and other war material and has possibilities for application in the field of medical diagnosis.

Xeroradiography is a fast, low-cost, dry, direct-positive, process for producing X-ray images. It is electrostatic rather than chemical in nature. Reusable plates and low-cost powders take the place of chemicals and films used in conventional radiography. In less than two minutes, with a minimum of effort, an industrial inspector can secure a shadow picture, similar to that on an X-ray negative, showing the internal condition of his product.

Xeroradiography has definite advantages over rapid film development processes in that it is entirely free of chemicals and employs reusable plates. Another advantage is that neither the image nor the xerographic plate is affected by any type of radiation including atomic radiation.

Electronic Selective Dispatcher Permits Private Conversations

The first all-electronic selective dispatching method for 2-way radio systems has been developed by the General Electric Commercial Equipment Division, Syracuse, N. Y. The method employs radically new equipment to permit private conversations between a dispatcher and an individual mobile unit, or a specific group of mobile units within a 2-way radio system.

The new equipment allows separation of a system into as many as ten groups. All individuals in a group hear a dispatcher's call, but when the called party responds, all other receivers in the group remain silent. A mobile operator, under the method, would hear fewer calls not intended for his attention, reducing the number of callbacks and repeats, and lessening driver fatigue. An electronic tone-sensitive device is attached to each receiver in the system. Each group of receivers is activated by a separate tone signal from the dispatcher's office.

The tone signals are within the 300–3,000-cycle range, permitting their use over any circuit which will pass voice, including telephone lines. The mobile receivers are activated within 1/2 second after the dispatcher pushes the control button.

The equipment attached to the mobile unit has no moving parts or contacts. It uses standard receiving-type tubes, and is directly applicable to any frequency-modulated communications receiver. No tuning or other adjustment is necessary with the new equipment, which is immediately applicable to either 6- or 12-volt power supply.

Reliability of the equipment is assured by an adequate safety margin for wide variations in power supply voltages, signal input, and ambient temperature. The equipment is not subject to false triggering, even with greatly overmodulated signals.

The device to be attached to the mobile units is small, and weighs only 3 pounds.

High-Resolution Video Unit Assures Isolated Monitoring

A new television picture monitor which will permit a television station to monitor video signals with full assurance that the monitor is not cutting into the picture signal resolution has been developed by Federal Telecommunication Laboratories, Inc., Nutley, N. J., research unit of the International Telephone and Telegraph Corporation.

Designated the *FTL-84A*, the new monitor is especially useful in the laboratory and production testing of television video amplifiers. The resolving power has been designed for operation well beyond the specified 600 horizontal lines minimum. The picture size is 14 inches.

The deflection circuits have been designed for stable operation and are independent of the separately driven pulse high-voltage supply. This permits the adjustment of horizontal linearity and size without concern for the effect on high voltage. The high-voltage supply provides 16 kv for a bright, crisp picture.

Two of World's Largest Motors Installed at Grand Coulee Dam

Two giant 65,000-horsepower synchronous motors, second to none in power and size, have been installed in the pumping plant at Grand Coulee Dam by engineers of the General Electric Company in co-operation with the United States Bureau of Reclamation.

The huge motors, each weighing more than 330 tons, will be used in the Bureau's Columbia Basin Irrigation Project, under a program designed to help irrigate a vast expanse of rich but dry land in south-central Washington.

The motors stand 25 feet high and measure 100 feet around the base. They will drive two of the world's largest pumps, each capable of supplying enough water to equal the daily requirements of the City of New York. When operating under optimum conditions, each pump will supply more than a billion gallons of water a day (50 tons a second) to help transform the locality into a highly productive farming area.

Precise Optical Straightedge Measures Flat Surfaces

By utilizing a beam of light as a straight-line reference, deviations of supposedly flat surfaces as small as plus or minus 0.00005 inch may be measured. This is made possible by the new optical straightedge made by the F. T. Griswold Manufacturing Company, Philadelphia, Pa., which consists of a lens and prism housing, and a feeler microscope with built-in illumination which rides along the surface under examination.

Made in standard lengths of approximately 3, 5, 10, and 13 feet, the housing rests on two blocks and the feeler, which includes the optical system, slides on the work surfaces. The errors, observed through the microscope, are indicated by the relative position of two indices. The distance between these indices is converted into linear measurement by reference to a micrometer thimble.

The surface contours may be recorded graphically by accessories attached to the equipment. Deviations, enlarged by 1,000, are traced for permanent record on co-ordinate paper as the feeler is moved from one end of the housing to the other.

Canadians Exploit Iron Ore with Aid of Hydroelectricity

New, privately constructed dams for hydroelectric power are planned by the Iron Ore Company of Canada, as part of its $200,000,000 program to exploit the rich new iron ore discoveries in northern Quebec and western Labrador.

The Lake Menihek dam, 30 miles south of the mining camp at Burnt Creek, will be of the earth-fill type, and will have a generating capacity of about 30,000 horsepower. It will also serve as a bridge across the lake for a railroad which now is being built to Burnt Creek from the St. Lawrence River port of Seven Islands, Quebec, 320 airline miles to the south.

Another dam will be built to furnish power for Seven Islands itself, a 150-year-old Hudson Bay Company post that has suddenly begun mushrooming as a supply point for the whole Iron Ore Company project. The Seven Islands dam will be on

One of the 330-ton, 65,000 - horsepower motors which will drive two of the world's largest pumps is being assembled in the new pumping plant at Grand Coulee Dam on the Columbia River

the nearby Marguerite River and, like the dam on Lake Menihek, will develop about 30,000 horsepower.

In the foreseeable future, hydroelectric developments on the largest scale in the world may take place in this region, according to mine officials. Geological surveys of Grand Falls, Labrador, show a potential of 5,000,000 horsepower—three times that of Niagara, while Muskrat Falls, 100 miles away, can develop 1,500,000 horsepower, it is estimated.

The dams are scheduled for completion in 1953, and the railroad in 1954. When operations are in full swing, 10,000,000 tons of ore a year are expected to come from the mines.

New Yarn-Testing Equipment Uses Photoelectric Recorder

New equipment to test evenness and to determine the weight of yarn of every known fiber, natural or man-made, has been developed by the research laboratories of Pacific Mills, Lawrence, Mass. The equipment uses a photoelectric recorder and other electronic devices made by General Electric Company. The Pacific Evenness Tester provides a permanent record of yarn thickness at the rate of 12 yards a minute.

The new tester determines actual fiber weight exclusive of moisture and oil content, without previous conditioning in standard atmosphere rooms. The unit was designed to test evenness, and to determine the weight of sliver, roving, and yarn from 4.5 ounces per 5 yards wool sliver to 100s worsted yarn, or the equivalent in any other fiber. The sliver or yarn is fed into the tester through a set of tongued and grooved rolls. The bottom grooved roll is positively driven through a flexible coupling by a 36-rpm gear reduction motor. The top tongued roll is friction-driven and is mounted on an arm, pivoted in a casting mounted on the base. The width of the grooves governs the capacity of the tester.

As the sliver or yarn runs between the top and bottom rolls, in the correct groove, variation in thickness causes a linear movement up or down of the top roll. This movement is converted into an electric impulse by a magnetic displacement gauge, which in turn is measured by a micrometer, magnified, and inked on graph paper by a photoelectric recorder.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, and carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Determining Phase Sequence

To the Editor:

I believe that the manner of ascertaining phase sequence by means of two wattmeters, as shown by Mr. Tschupp in his Letter to the Editor (*EE, May '51, p 469*), is generally known although not generally stated in textbooks. It is discussed briefly on page 149 of the textbook "Electric Circuits and Machines," and is generalized through problem 35 on page 165.[1]

About 10 years ago an experiment having this procedure in mind was introduced into one of the senior laboratories here. One set of double secondary windings of a 3-phase transformer bank was connected in delta, the other set in Y. The secondaries were closed on each other through current-limiting reactors and a 3-pole jack box which served both as a line switch and a means of metering. Students had access only to the box at the station with its incoming and outgoing leads.

Requirements in the experiment were to ascertain the magnitudes of line voltage, line current, active power in kilowatts, reactive power in kilovolt-amperes, the power factor, the direction of power flow, and to label the lines properly for voltage sequence. Each party had to select its own instruments for any measurements it wished to make. Although not so informed, the students were to obtain voltage sequence using two wattmeters and an artificial capacitor load connected to the terminals of the metering box.

REFERENCE

1. Electric Circuits and Machines (book), **B. L. Robertson, L. J. Black.** D. Van Nostrand Company, Inc., New York, N. Y., 1949.

B. L. ROBERTSON (F '43)
(University of California, Berkeley, Calif.)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ADVANCES IN ELECTRONICS, Volume 3. Edited by L. Marton. Academic Press, Inc., New York, N. Y., 1951. 357 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $7.50. As in the past volumes, this book presents an up-to-date review of outstanding developments in the rapidly expanding field of electronics both in the United States and abroad. Each of the nine chapters summarizes important progress in theory, techniques, and devices made in the past year. Such pertinent subjects are covered as microscopy, tube design, miniaturisation, magnetron theory, communications theory, and network synthesis. Reference lists follow each chapter.

L'ALLUMAGE ÉLECTROSTATIQUE DES MOTEURS A EXPLOSION (Publications Scientifiques et Techniques du Ministère de l'Air, Number 244). By M. Point, preface by N. J. Félici. En Vente au Service de Documentation et d'Information Technique de l'Aéronautique, 2 Rue de la Porte-d'Issy, Paris (15e), France, 1950. 82 pages, diagrams, charts, tables, 10⅛ by 7 inches, paper, 450 frs. Part I of this publication deals with the fundamentals of internal-combustion engine ignition and the production of a spark by induction equipment. Part II discusses the principles and operation of electrostatic ignition, including a comparison of different systems.

ALTERNATING CURRENT FUNDAMENTALS. By J. J. De France. Prentice-Hall, New York, N. Y., 1951. 216 pages, illustrations, diagrams, charts, tables, 8½ by 5½ inches, linen, $4.65. Written especially for students of electronics, this book develops a-c theory from the "electronic" rather than the usual "power" point of view. Prerequisites include a good foundation in d-c principles, both inductance and capacitance, and mathematics, including algebra, trigonometry, and the use of the slide rule. The review problems at the end of the chapters summarize the highlights of each chapter.

ARTIFICIAL FIBRES. By R. W. Moncrieff. John Wiley and Sons, New York, N. Y., 1950. 313 pages, illustrations, diagrams, charts, tables, 9¼ by 5½ inches, linen, $4.50. This book presents pertinent material on man-made fibers. Of the five main divisions, the first deals with the structure and properties of fibers in general. In the second part, the history, chemical nature, manufacture, properties, dyeing, and uses of regenerated cellulosic and alginic fibers are discussed. Parts III and IV treat in the same manner the regenerated protein fibers and synthetic fibers, respectively. In the last section, the processing of fibers is considered. Suggestions for further reading are given at the ends of the chapters.

ATOM MOVEMENTS, a Seminar on Atom Movements at the 32nd National Metal Congress and Exposition, Chicago, October 21–27, 1950. Sponsored and published by American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio, 1951. 250 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, fabrikoid, $5.00. Discussing the detailed mechanisms of atom movements, this volume contains papers on various aspects of the diffusion process. It covers several descriptions of the process from various viewpoints; methods for obtaining, analyzing, and presenting diffusion data; diffusion during high-temperature oxidation; diffusion of gases in metals; diffusion during sintering; and grain-boundary migration. A summary of our current understanding of atom movements and suggestions for new experiments are presented.

BIBLIOGRAPHY ON INDUSTRIAL RADIOLOGY 1948–1950, Third Supplement to INDUSTRIAL RADIOLOGY. By H. R. Isenburger. St. John X-Ray Laboratory, Califon, N. J., 1951. 19 pages, 11½ by 8¼ inches, stiff paper, $2.00. Approximately 500 additional references are contained in this continuation of a series which now runs to some 2,500 entries over-all. The scope is broad, and a wide range of magazines, both domestic and foreign, is covered. The arrangement is chronological only; no author or subject index.

COSTS, BUDGETING AND ECONOMICS OF INDUSTRIAL RESEARCH, Proceedings of the First Annual Conference on Industrial Research, June 1950, sponsored by the Department of Industrial Engineering, Columbia University. Edited by D. B. Hertz and A. H. Rubenstein. King's Crown Press, Columbia University, New York, N. Y., 1951. 261 pages, diagrams, tables, 8½ by 5½ inches, paper, $4.50. This volume contains the abridged and edited proceedings of the first annual Conference on Industrial Research held at Columbia University in June 1950. The theme of the Conference emphasized costs, budgeting, and economics, but other aspects also were considered. In addition to the papers, summaries of the clinic session discussions are given. A short bibliography is included.

COURS DE CALCUL MATRICIEL APPLIQUÉ. By M. Denis-Papin and A. Kaufmann. Éditions Albin Michel, 22 rue Huyghens, Paris, France, 1951. 304 pages, illustrations, diagrams, charts, tables, 10 by 6¾ inches, paper, 1,600 frs. A detailed explanation of matrix calculation, especially as applied to vibration dynamics, quadripole theory, strength of materials, and so forth. Calculating machines and their use are discussed, and review summaries are provided covering determinants and the roots of equations higher than second degree.

CRYSTAL GROWTH. By H. E. Buckley. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1951. 571 pages, illustrations,

diagrams, charts, tables, 8¾ by 5½ inches, linen, $9.00. Covering both theory and practice, this book is a broad review of the subject from the chemical viewpoint. Beginning with background theory and the artificial preparation of crystals, the author considers the main features of the apparatus and principles involved. Various theories of crystal growth then are presented, followed by an intensive investigation concerning types of crystallization and dissolution phenomena. Then the nature and effects of impurities are discussed in detail. A final chapter considers peculiarities in crystal growth. An extensive bibliography is included.

DIMENSIONAL ANALYSIS AND THEORY OF MODELS. By H. L. Langhaar. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1951. 166 pages, illustrations, charts, tables, diagrams, 9¼ by 6 inches, linen, $4.00. This book is devoted to the principles of dimensional analysis which treat the general form of equations that describe natural phenomena. The first four chapters deal with basic principles and develop them mathematically. Chapter 5 covers the theories of similarity and model testing. The remaining five chapters are specific applications of dimensional analysis. A knowledge of the principles of physics and engineering usually presented in the first three years of an engineering curriculum is assumed.

EFFECTIVE MANAGEMENT THROUGH PROBABILITY CONTROLS, How to Calculate Managerial Risks. By R. K. Mueller. Funk and Wagnalls Company, New York, N. Y., in association with Modern Industry Magazine, 1950. 310 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth $5.00. A thorough treatment of how statistics can be used to calculate managerial risks, as well as to predict and analyze groups of events in business. It is written from a practical application point of view to guide administrators interested in improving performance in their service, staff, and administrative activities, including finance, personnel, marketing, production, and research.

ELECTRIC POWER STATIONS, Volume 2. By T. H. Carr. Third edition. Chapman and Hall, Ltd., London, England, 1951. 821 pages, illustrations, diagrams, charts, tables, 8¾ by 5½ inches, cloth, 75s. The first two chapters on condensing plant and water treatment continue the material started in Volume I on the mechanical equipment of (steam) electric power stations. Succeeding chapters give detailed information on alternators, transformers, reactors, switchgear, cables, station auxiliaries, protective equipment, and lubricating, insulating, and fuel oils. The economics and maintenance of stations are considered, and separate chapters deal with hydroelectric, diesel-electric, gas-turbine, wind, atomic, and other types of power plants.

ELECTRICAL REFRESHER FOR PROFESSIONAL ENGINEERS LICENSE EXAMINATION. By J. D. Constance; apply to author, John D. Constance, 625 Hudson Terrace, Cliffside Park, N. J., 1951. No pagination, illustrations, diagrams, tables, 11 by 8½ inches, stiff paper, $2.00. Based on lectures sponsored by the Metropolitan Section of the American Society of Mechanical Engineers, this book is a comprehensive collection of problems compiled from previous professional engineers license examinations, together with their solutions. It is intended as a companion to the volume, "Refresher Notes," which covers other parts of the Basic Engineering Sciences section of the examination.

ÉLECTRICITÉ. By Y. Rocard. Masson et Cie, Éditeurs, 120 Boulevard Saint-Germain, Paris (6e), France, 1951. 538 pages, diagrams, charts, tables, 9½ by 6½ inches, linen, 2,220 frs. bound, (1,800 frs. unbound). This comprehensive treatise covers the basic theory and characteristics of electrostatics, electrodynamics, magnetism, a-c practice, and electronics. Modern developments in these fields are covered, particularly with respect to electronic applications. Separate sections are devoted to electrolysis and to the systems of units currently in use.

ELECTROMAGNETIC PROBLEMS OF MICROWAVE THEORY (Methuen's Monographs on Physical Subjects). By H. Motz. John Wiley and Sons, New York, N. Y.; Methuen and Company, Ltd., London, England, 1951. 184 pages, diagrams, charts, tables, 6⅞ by 4¼ inches, stiff cardboard, $2.00. The aim of this small book is to illustrate methods of analysis by thoroughly worked examples, selecting those methods which have wide application. Topics covered include the following: theory of velocity modulation; klystron theory; mode selection in cavity magnetrons; field relations and calculations; antenna impedance; and the theory of discontinuities in wave guides.

ELECTRONIC MOTOR AND WELDER CONTROLS. By G. M. Chute. McGraw-Hill Book Company, New York, N. Y; Toronto, Ontario, Canada; and London, England, 1951. 348 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $6.50. This book considers the two major groups of tube-operated equipment which are employed in resistance welding control and for the control of motors in a wide variety of industrial processes. Descriptions of recent types of welding control include combinations of novel basic electron-tube circuits as used in the all-tube sequence timers and the frequency-change type of control. Improved electric circuits of some of the general-purpose types of electronic motor control are covered as well as closed-cycle motor-control systems.

ENGINEERING AND WESTERN CIVILIZATION. By J. K. Finch. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 397 pages, illustrations, diagrams, charts, maps, tables, 9¼ by 6 inches, linen, $5.00. This book outlines the history of engineering from the earliest beginnings, some 50 centuries ago, to modern times, noting and commenting upon the accompanying economic and social conditions and their relation to technological development and progress. A conscious attempt is made to avoid technical details and to present the story in a suitable historical perspective. An extensive annotated bibliography is provided for those wishing further details.

ENGINEERING MATERIALS MANUAL. Edited by T. C. DuMond, and published by *Materials and Methods*, Reinhold Publishing Corporation, New York, N. Y., 1951. 386 pages, illustrations, diagrams, charts, tables, 11¼ by 8½ inches, stiff cardboard, $4.50. A collection of special sections originally published in the magazine, *Materials and Methods*, this book provides descriptive information and reference data on the engineering materials used in industry. Its 28 sections cover such materials as iron, steel, stainless steel, aluminum, magnesium, copper alloys, plastics, rubber, ceramics, and several types of finishes and coatings. Two of the relatively new materials considered are beryllium copper and high-strength, low-alloy steels.

ENGINEERS OF THE SOUTHWEST PACIFIC 1941–1945, Volume VIII. CRITIQUE. By the Office of the Chief Engineer, General Headquarters Army Forces, Pacific. Reports of Operations, United States Army Forces in the Far East, Southwest Pacific Area, Army Forces, Pacific, 1950. 451 pages, illustrations, charts, maps, tables, 11½ by 9 inches, cloth, $5.75, for sale by Superintendent of Documents, Government Printing Office, Washington 25, D. C. Reviewing the work of the Corps of Engineers, this volume is a compilation of conclusions, criticisms, and recommendations, presented in narrative form by campaign from the beginning to the end of World War II in the Southwest Pacific. Problems covered include engineer organization, administration, intelligence, amphibian and combat operations, construction, capacity and adequacy of personnel, training, and supply. Bibliographies are placed at the end of each chapter, and a chronology, a glossary, and a guide to the system of documentation employed are appended at the end of the volume.

EYES IN INDUSTRY. By D. A. Campbell, W. J. B. Riddell, and Sir A. S. MacNalty. Longmans, Green and Company, New York, N. Y.; London, England; Toronto, Ontario, Canada, 1951. 234 pages, illustrations, diagrams, charts, colored plates, tables, 10 by 6¾ inches, cloth, $6.50. Written in clear and simple language, this book deals with the problems of vision, lighting, and color, and stresses the importance of visual efficiency and harmony wherever people work. In three parts: part 1 describes the structure and function of the eyes and the conditions which influence sight; part 2 considers the nature of eye injuries and the risks to which both agricultural and industrial workers are liable; part 3 is concerned with industrial injuries from the administrative and public health standpoints.

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ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

FERROMAGNETISM. By R. M. Bozorth. D. Van Nostrand Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 968 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, linen, $17.50. A source book for engineers and students, this book covers the entire field of ferromagnetism in four main divisions. Part I is introductory, covering concepts of ferromagnetism and factors that effect magnetic quality. Part II is a systematic description of the magnetic and related properties of known ferromagnetic materials. Part III is devoted to the physical phenomena of ferromagnetism. Part IV and the Appendices describe various conventional and special methods of measurement of magnetic qualities and tabulate the more important physical and magnetic properties of ferromagnetic materials.

F-M SIMPLIFIED. By M. S. Kiver. Second edition. D. Van Nostrand Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 458 pages, illustrations, diagrams, charts, tables, 8¼ by 5½ inches, cloth, $6.50. This book not only presents the facts concerning frequency modulation but also indicates and helps bridge the gap between it and amplitude modulation. The second edition has been completely revised and reorganized. After the fundamentals of frequency modulation are presented in the first three chapters, a chapter is devoted to the propagation, reception, and transmission of frequency-modulated signals. The next six chapters completely analyze frequency-modulated receivers. Circuit alignment, commercial frequency-modulated receivers and their servicing and maintenance are then treated. The final three chapters consider frequency-modulated transmitters. Questions follow each chapter.

(THE) FOURIER INTEGRAL AND CERTAIN OF ITS APPLICATIONS. By N. Wiener. Dover Publications, New York, N. Y., 1st American Printing of the 1933 edition. 201 pages, tables, 8¼ by 5½ inches, linen, $3.95. This book studies the Fourier integral as a link between harmonic analysis and mathematical theory, physics, and engineering. It is based on a series of lectures given at the University of Cambridge in 1932, and considers the relationship of the Fourier transform to the Plancherel theorem, a discussion of an absolutely convergent Fourier Series and of a Tauberian theorem, and the concept of the spectrum. A bibliography is included.

FOURIER TRANSFORMS. By I. N. Sneddon. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1951. 542 pages, diagrams, charts, tables, 9¼ by 6 inches, linen, $10.00. Suitable for use by those interested in the boundary value problems of physics and engineering, this book emphasizes the applications of the theory of Fourier transforms and such related topics as Laplace, Mellin, Hankel transforms, finite transforms, dual integral equations, and the Wiener-Hopf procedure. The first three chapters contain basic theory, and the remaining seven are devoted to the illustration of the use of this theory in the theory of vibration, conduction of heat, slowing down of neutrons, hydrodynamics, atomic and nuclear physics, and elasticity.

FUNDAMENTALS OF ELECTRICAL ENGINEERING. By F. H. Pumphrey. Prentice-Hall, Inc., New York, N. Y., 1951. 668 pages, illustrations, diagrams, charts, tables, 9¼ by 5½ inches, linen, $7.65. Intended as a text for a 2-year course for nonelectrical engineering students, this book provides the background needed for the application, selection, operation, and maintenance of various types of electrical equipment. Only a minimum of design computation is included. Electronic techniques are treated in detail. In addition to an explanation of physical phenomena, sufficient quantitative material is provided so that simple amplifiers and electronic switches can be designed.

GAS DISCHARGE LAMPS, Principles, Characteristics, Applications. By J. Funke and P. J. Oranje, translated by G. Ducloux, published by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands, also Elsevier Press, Inc., 402 Lovett Boulevard, Houston 6, Texas, and Cleaver-Hume Press, London, England, 1951. 270 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $4.25; 30s. Of interest to those concerned with the physics of electric discharge, this book surveys the existing types of discharge lamps, together with their relative possibilities, advantages and disadvantages, characteristics, and principles. Part I considers the fundamental principles of this type of

lighting. Part II is devoted to the discussion of such types of lamps as sodium lamps, high-pressure and super high-pressure mercury vapor lamps, and low-pressure tubular fluorescent lamps. In the appendix a brief survey of the concepts and units employed in lighting technology is given as well as a bibliography of pertinent articles and books.

GAS TURBINES. By H. A. Sorensen. Ronald Press Company, New York, N. Y., 1951. 460 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, linen, $6.50. The object of this book is to present a thorough and fundamental treatment of the thermodynamic principles, the elements of design, and the general construction features of the gas turbine. The material is organized by topic or function rather than by type of plant. Special emphasis is placed on the axial-flow compressor and turbine. A knowledge of engineering thermodynamics is required. Treatment of aerodynamics and gas flow is minimized. Operating data are included to indicate current performance.

HEATING VENTILATING AIR CONDITIONING GUIDE, Volume 29, 1951. American Society of Heating and Ventilating Engineers, 51 Madison Avenue, New York, N. Y.; 1951. 1,456 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, fabrikoid, $7.50. A standard reference book, its 50 chapters are devoted to such varied topics as the fundamentals of thermodynamics, the physiological bases of heating and air conditioning, the calculation of heating and cooling loads of enclosed spaces, and descriptions of systems and apparatus such as: steam-heating systems, panel heating, electric heating, refrigeration, and drying systems. The many changes made in this new edition are listed in the preface. There is a large indexed section of condensed manufacturers' catalogues.

HIGH-SPEED AERODYNAMICS. By W. F. Hilton. Longmans, Green and Company, New York, N. Y.; London, England; Toronto, Ontario, Canada, 1951. 598 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, linen, $8.50. This comprehensive and up-to-date book covers the principles of high-speed flight and of the design and construction of subsonic and supersonic aircraft and rockets. In four parts: Part I is devoted to subsonic and transonic flows; Part II to supersonic flow; Part III to wind tunnels; and Part IV to general considerations on such topics as thermodynamics, jet propulsion, unsteady flow, and so forth.

LOCOMOTIVE CYCLOPEDIA of American Practice, 1950–1952. Edited for Association of American Railroads—Mechanical Division, by C. B. Peck and Associates. 14th Edition. Simmons-Boardman Publishing Corporation, New York, N. Y., 1950. 1,028 pages, illustrations, diagrams, charts, tables, 11¼ by 8½ inches, fabrikoid, $10.00. The major changes in this standard reference include nine new sections dealing with diesel-electric locomotives; a revision and trimming to eliminate obsolete data in the sections on steam locomotives; a new section on the gas-turbine-electric locomotive; new designs in the all-electric locomotive; inclusion of data on the standard, export, industrial, and mine electric locomotives in one section; and three new sections on diesel-electric maintenance and servicing. The usual dictionary of locomotive terms is included as well as the extensive technical data.

MATHEMATICAL METHODS IN ELECTRICAL ENGINEERING. By M. B. Reed and G. B. Reed. Harper and Brothers, New York, N. Y., 1951. 338 pages, diagrams, charts, tables, 9½ by 6¼ inches, linen, $5.00. This book presents the streamlined essentials of mathematics which an electrical engineer is likely to find useful in his professional career. Attention is centered almost wholly on the manipulative aspects of the material presented. Such topics are covered as imaginary numbers, linear algebraic equations, matrix algebra, vector analysis, Fourier series, Bessel functions, partial differential equations, and analytic functions of a complex variable.

(THE) NATURE OF METALS (Series for Self-Education). By B. A. Rogers. Published jointly by American Society for Metals, Cleveland, Ohio, and Iowa State College Press, Ames, Iowa, 1951. 248 pages, illustrations, diagrams, charts, tables, 7¾ by 5 inches, cloth, $3.00. Addressed to nonmetallurgists who wish to know more about this subject, this book surveys the metallurgy of our common metals and alloys in a simple and direct manner. The structure of metals and alloys, movement of atoms in solid metal, the story of steel, metal deformation, recrystallization, and problems of oxidation and corrosion are covered.

(THE) NEW PHYSICS, Talks on Aspects of Science. By Sir C. V. Raman. Philosophical Library, New York, N. Y., 1951. 144 pages, 8¼ by 5½ inches, linen, $3.75. Originally delivered as a series of radio talks to the Indian public, this book discusses mainly the scientific aspects of those parts of nature with which all of us come into contact but seldom try to understand. It covers such topics as light, color, soil, water, weather, glass, atmospheric electricity, the structure of the crystal, cosmic rays, and the stellar universe.

NEW THEORY OF GRAVITATION. By J. Mandelker. Philosophical Library, 15 East 40th Street, New York, N. Y., 1951. 25 pages, diagrams, 8¼ by 5½ inches, linen, $2.75. The author maintains that the outwardly directed radiational force of matter-energy is co-ordinated as the counterforce to the inwardly directed force of gravitation. The mathematical-physical form and relationship is developed in the main body of the book which includes a theoretical derivation of the gravitational constant. The final chapter presents a natural system of physical units.

ORTSKURVENGEOMETRIE IN DER KOMPLEXEN ZAHLENEBENE. By W. Michael. Verlag Birkhäuser, Basel, Switzerland, 1950. 93 pages, diagrams, tables, 9½ by 6¼ inches, cloth, 11.50 Sw. Frs. Of interest to those in the electrotechnical field, this book provides a primarily analytical treatment of locus-curves. It develops simple geometrical relations which permit the exact construction of special curves. The theoretical results are illustrated by various numerical examples. Only rational curves are considered.

DIE ORTSKURVENTHEORIE DER WECHSELSTROMTECHNIK. By G. Oberdorfer. Second edition. Franz Deuticke, Vienna, Austria, 1950. 100 pages, diagrams, charts, tables, 9¼ by 6½ inches, paper, $4.00. Beginning with introductory mathematical operations involving complex numbers and vectors, this book proceeds to a detailed treatment of the theory of loci with diagrams representing a wide range of conditions. Examples of practical applications in a-c calculations are given.

PULSE TECHNIQUES. By S. Moskowitz and J. Racker. Prentice-Hall, New York, N. Y., 1951. 300 pages, illustrations, diagrams, charts, tables, 8¾ by 5½ inches, linen, $6.65. The purpose of this book is to enable individuals with an electrical engineering background to analyze and design circuits for transmission and utilization of pulses. The special mathematical tools needed, Fourier and Laplacian transforms, are derived and their use explained. The pulse response of both linear and nonlinear networks is covered and pulse measurement methods and the design of communication and aerial navigation equipment using pulses are reviewed.

QUANTUM THEORY. By D. Bohm. Prentice-Hall, New York, N. Y., 1951. 646 pages, diagrams, charts, 9½ by 6 inches, linen, $10.00. This book provides a basically qualitative and physical presentation of fundamental principles, supplemented with a broad range of specific applications that are worked out in considerable mathematical detail. Parts I and II present physical and mathematical formulations of the quantum theory. Part III is devoted to applications to simple systems, Part IV to methods of approximate solutions of Schrödinger's equation, Part V to the theory of scattering, and the last part to the quantum theory of the process of measurement.

LE RADAR. By R. Leprêtre, preface by M. de Broglie. Gauthier-Villars, Imprimeur-Éditeur, 55 Quai des Grands-Augustins, Paris, France, 1951. 294 pages, illustrations, diagrams, charts, tables, 9¾ by 6½ inches, paper, 2,000 frs. Following an historical summary and a general description of radar methods, the book continues with the theory of wave propagation and the characteristics of radar transmission. The essential components of radar apparatus are described in detail.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

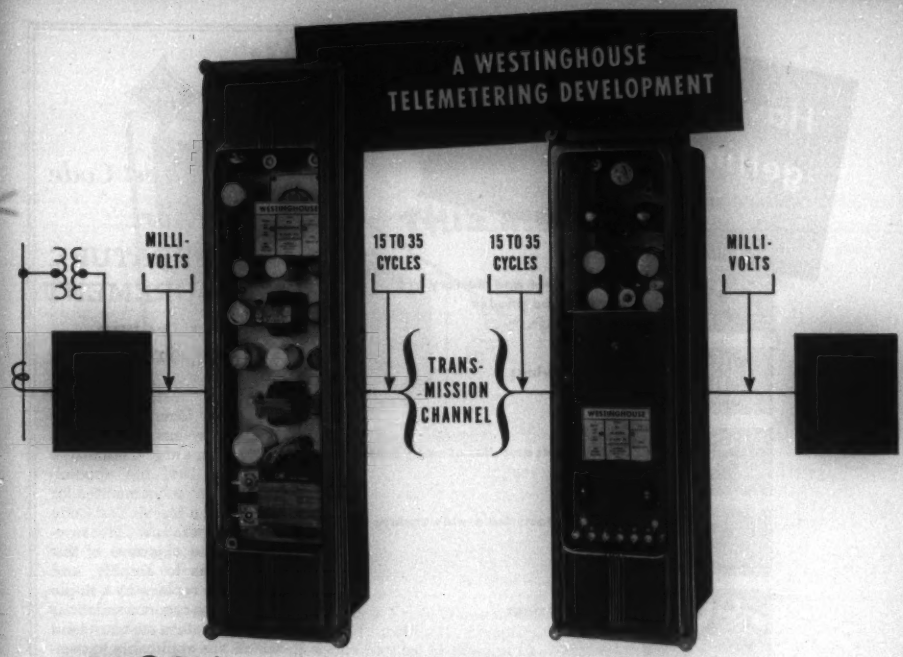
ASTM Standards on Metallic Electrical Conductors. Included in this compilation are tentative specifications and test methods covering: 1. copper, copper alloy and copper-covered steel wire; stranded conductors; rods, bars, and shapes; pipes and tubes; 2. aluminum wire; stranded conductors; rods and bars; 3. galvanized steel core wire; and galvanized iron and steel guy, messenger, span, overhead ground, and line wire. Other specifications cover nonferrous materials. General methods include test for resistivity of electrical conductor materials; tension testing of metallic materials; and test for rockwell hardness and superficial hardness of metallic materials. 232 pages. Copies are available from the American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa., at $2.50 each.

Aging Characteristics of Electrical Insulation. A new procedure which has been developed by the Naval Research Laboratory to determine the aging characteristics of electrical insulation is described. The procedure uses coils wound and subjected to stresses experienced by motor windings to duplicate physical factors which together with temperature, influence the aging characteristics. Thus, means are provided for checking all factors which influence insulation life, such as temperature, dielectric and mechanical stresses, and contaminants. 13 pages including photographs, designs, graphs, and tables sells for $0.50 per copy. Available from: *PB 102619*, Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

Two-Way Radio for the Transportation Industry. The basic Fleetfone systems available for service in the 30–50 megacycle frequency band, are covered and explanations are given of the advantages of such service for various segments of the transportation industry. The 8-page illustrated booklet tells how to obtain a permit from the Federal Communications Commission and contains information to determine whether it is practical to use 2-way radio for any particular application. Copies are available without charge from: Advertising Section, Engineering Products Department, Radio Corporation of America, Camden, N. J.

How to Prepare Your Plant for Atomic Attack. This booklet presents the latest factual information about the atomic bomb, its destructive potential, and its limitations; a guide to plant management in organizing personnel to cope with possible plant disasters; and recommendations for strengthening plant construction and sustaining production in the face of bomb attack. 32 pages, illustrated. Copies may be obtained without cost from Walter Kidde and Company, Inc., Department A, 675 Main Street, Belleville, N. J.

Uniform Face-to-Face Dimensions for Flanged Control Valve Bodies. Dimensions covered are the face-to-face body dimensions for flanged-end valves of both cast iron and steel through 600-pound flange ratings. Sizes included are ½ through 8 inches. Only flanged valves which are in the category of diaphragm actuated control valves of the plug type are included. Copies are available at $0.25 per copy from the Instrument Society of America, National Office, 921 Ridge Avenue, Pittsburgh, Pa.



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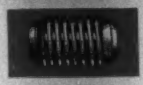

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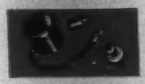

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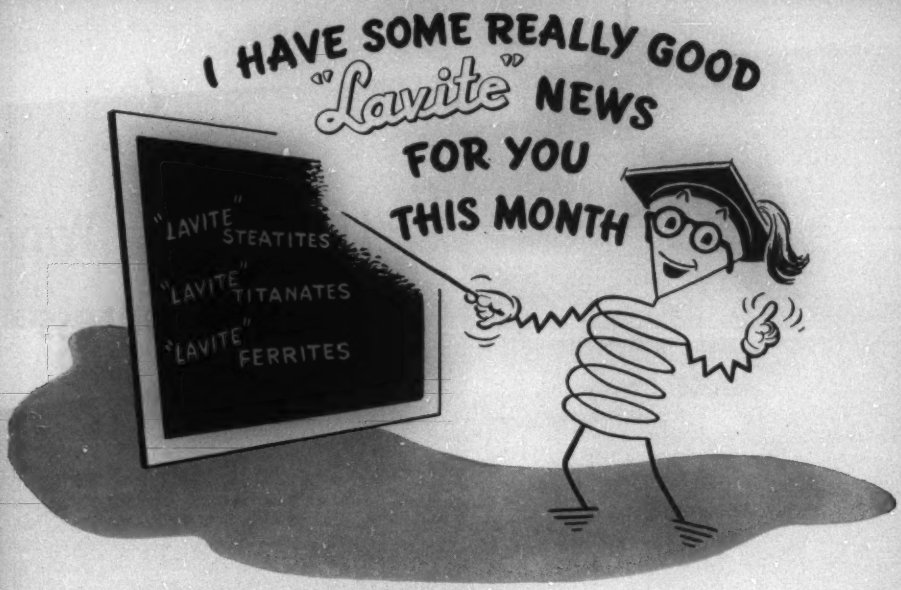

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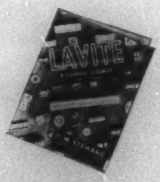

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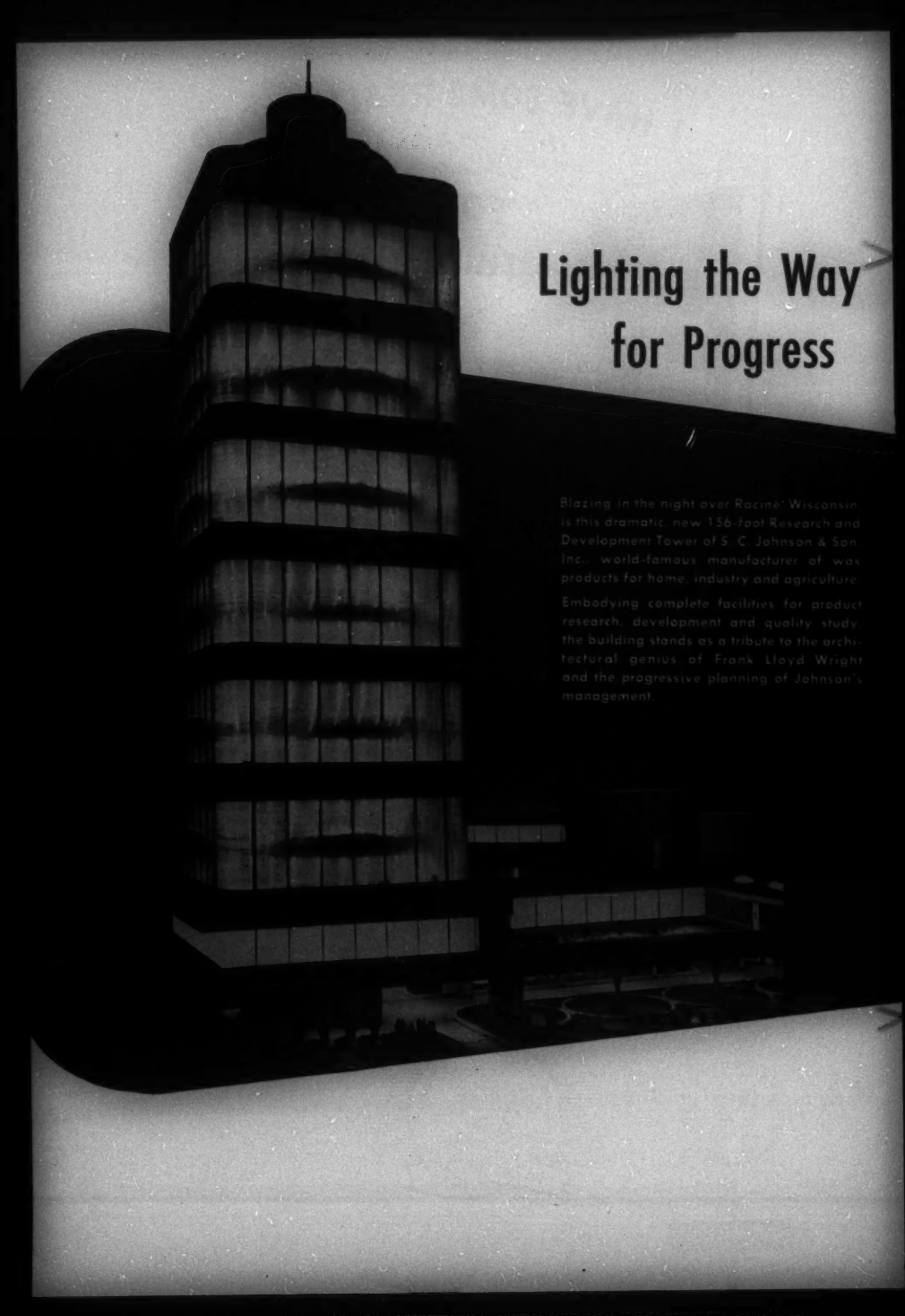
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INDUSTRIAL NOTES ....

Westinghouse Expands. A 1/2-mile long manufacturing plant to be used for the production of jet engine components and, after defense needs are met, for electric home appliances, will be built near Columbus, Ohio; a glass plant to manufacture bulbs for incandescent lamps will be built in Hot Springs, Ark.; and a wholly owned subsidiary, the Canadian Westinghouse Supply Company, which will distribute products of the Canadian Westinghouse Company, Ltd., in principal trading centers throughout Canada, has been formed, the Westinghouse Electric Corporation has announced. Westinghouse also has moved its Northwestern District headquarters in Chicago, Ill., from 20 North Wacker Drive to a 46,000-square-foot office in the Merchandise Mart. The new office features fluorescent sunlamps, germ-killing Sterilamps, soundproofing, and complete air conditioning.

American Steel and Wire Retirement. Ernest E. Louis, assistant to Vice-President, Sales, the American Steel and Wire Company, a United States Steel Subsidiary, has retired after 39 years of continuous service.

Sylvania to Build Metallurgical Lab. Sylvania Electric Products, Inc., has announced plans for a new metallurgical laboratory at Sylvania Center, the company's 57-acre research site at Bayside, L. I., N. Y. The new building will be devoted largely to metallurgical research for the Atomic Energy Commission and to other government work.

Western Electric and I. T. & T. Sign Telecommunication Licensing Agreement. A world-wide nonexclusive cross-licensing patent agreement covering substantially the entire field of telecommunications, both in manufacture and operation, has been concluded between the Western Electric Company, Inc., for itself, and the American Telephone and Telegraph Company and their subsidiaries on the one hand, and International Telephone and Telegraph Corporation and its subsidiaries on the other. Under the agreement, the two companies license each other to use inventions made prior to and during a minimum period of six years, from January 1, 1951, to December 31, 1956, and, unless terminated on that date by one year's prior notice by either party, will continue indefinitely subject to termination in like manner on any anniversary thereafter.

Kollsman Names Chief of Radio Communications. Jay E. Browder has been appointed chief of the radio communications engineering section of the Kollsman Instrument Corporation, a subsidiary of Standard Coil Products Company, Inc.

RCA Tube Plant Opens in Cincinnati. The Radio Corporation of America's new electron tube manufacturing plant, devoted exclusively to the production of miniature and subminiature tubes, was opened recently in Cincinnati, Ohio. The plant was dedicated to the memory of John G. Wilson, late Executive Vice-President in charge of the RCA Victor Division.

Six Subsidiaries of G-E Become Departments of the Parent Company. Six manufacturing affiliates of the General Electric Company have become departments of the parent company. The affiliates are Carboloy Company, Inc., the General Electric X-Ray Corporation, Locke, Inc., Telechron, Inc., Monowatt, Inc., and The Trumbull Electric Manufacturing Company. As departments, these six subsidiaries will continue to operate under their present management, and their products will continue to be marketed under their existing trade names.

Bendix Purchases Pennsylvania Plant. The Bendix Aviation Corporation has purchased the South Montrose Manufacturing Company, South Montrose, Pa., and has made it a division of the parent company, to be known as the Montrose Division. It will be under the supervision of Raymond P. Lansing, Vice-President and group executive in charge of the Eclipse-Pioneer, Pioneer Central, Scintilla Magneto, and Red Bank divisions of Bendix.

Raytheon Sells Russell Subsidiary. The Raytheon Manufacturing Company has sold the Russell Electric Company, a subsidiary which manufactures fractional horsepower motors, to Charles Frost, New York, N. Y.

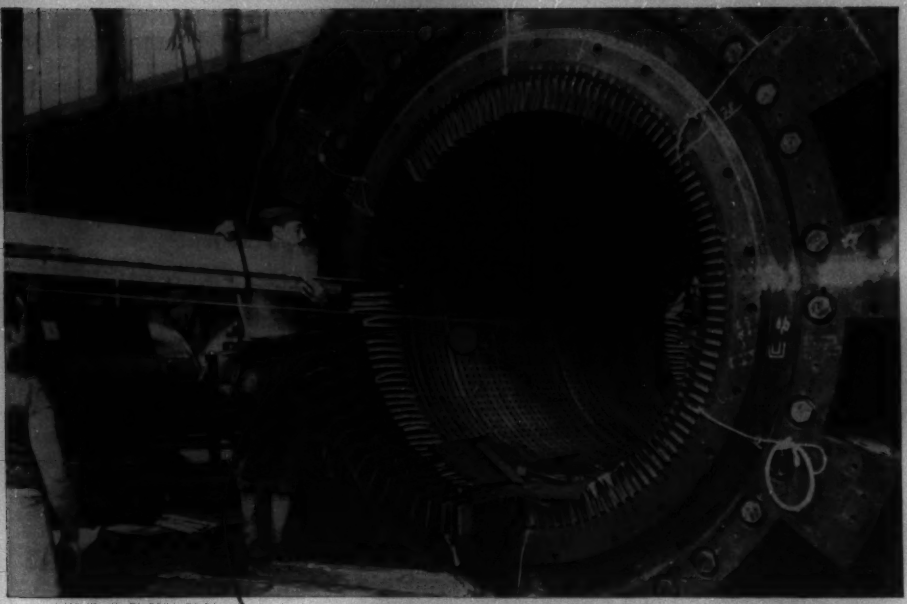
Battelle to Construct $1,000,000 Laboratory. Battelle Institute, Columbus, Ohio, has begun construction on a new million-dollar laboratory building, as a result of increased demands for research services in behalf of the nation's defense effort.

Marcus Transformer Increases Facilities. The Marcus Transformer Company has added an annex to their present plant in Hillside, N. J., which will extend their productive space by 50 per cent.

Philips Licenses General Ceramics to Make Magnetic Ferrites. Philips Laboratories, Inc., has granted to the General Ceramics and Steatite Corporation, Keasbey, N. J., a license under a number of patents pertaining to magnetic ferrites and their manufacture. Suits which were pending for alleged patent infringement have been withdrawn.

G-E Appointments. The General Electric Company has announced the following appointments: John T. Halleran, manager, Fort Edward and Hudson Falls operations, transformer and allied product divisions, Fort Edward, N. Y.; J. G. Hodge, manager, wage rates for the Schenectady, N. Y.,

(*Continued on page 22A*)



National gave this generator brand-new power

In the illustration at the top of the page the coil bars are being drawn into position. The lower illustration shows the coils being connected to the leads. This 3-phase, 50-cycle, 13,800-volt generator develops 45,000-kva at 1500-rpm.

Extra flexibility was needed in this rebuilding job. When the generator failed it was necessary to find someone who was equipped to handle the specialized repairs which were required. National was chosen. National engineers and technicians completely redesigned the stator windings; the National shops produced the bar design low-loss Roebel transposition type coils; and a National engineer was right there on the ground to supervise the actual rewinding of the generator. The result? A stator which gives more power at a lower operating temperature.

National can do the same for *your* motors or generators, whether they are special or not. Our experience and equipment are ready to work for you and to lower your power costs. Write or wire (or cable NATCOIL) *today*.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

Pick a Number

FROM 1 TO 5,348

...and you've got exactly the RIGHT RELAY FOR YOUR JOB!

With the Struthers-Dunn array of 5,348 relay types to choose from, it's both easy and economical to get a unit to match your mechanical and electrical specifications exactly. No lost time, money and effort in trying to utilize units that are only "almost right" for your particular job!

Write for condensed Catalog H for data on the most widely-used Struthers-Dunn types.

STRUTHERS-DUNN

5,348 RELAY TYPES

STRUTHERS-DUNN, INC., 150 N. 13th ST., PHILADELPHIA 7, PA.

BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI
CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES
MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PITTSBURGH
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MINIMIZATION of INTERFERENCE from RADIO-FREQUENCY HEATING EQUIPMENT

This report on a recommended practice reviews the theoretical aspects of the interference problem and then outlines procedures which should be followed; which may be applied both in construction and as remedial measures where interference exceeds limits specified in FCC rules. Price: $.80; 50 percent discount to AIEE members. Address:

AIEE ORDER DEPARTMENT
33 West 39th Street
New York 18, N. Y.

8-51

American Standard for POOL CATHODE MERCURY-ARC POWER CONVERTERS

Sponsored and published by AIEE, this standard (C34.1–1949), applies to all types of mercury-arc power converters, employing rectifying devices with mercury pool cathodes and used for power conversion purposes, including mercury-arc power rectifiers and inverters, electronic frequency changers and converters used with electronic motors when these equipments employ mercury-arc rectifying devices with pool cathodes. Price: $1.20; 50 per cent discount to members of the AIEE.

Address:

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8-51

Instrument NEWS

Spoilage Costs Cut 90% With G-E Roughness Scales

Air Maze Company, Cleveland, Ohio, manufacturers of filters for all purposes say that their G-E surface roughness scales and specimens cut spoilage costs 90% which otherwise would have increased manufacturing expenses. "They have provided us with real savings in both time and money," says H. W. Matlock, chief draftsman for Air Maze.

Daily use is made of the roughness specimens in preparing the specifications and blueprints for component filter parts. Then, with the handy lightweight scales, Air Maze makes certain that the finishes on parts received from their vendors are correct. When there is a question as to the suitability of a standard part, they end the argument.

G-E surface roughness scales and specimens are particularly adaptable when any parts, manufactured by several subcontractors or by different departments in one manufacturing plant, must have uniform surfaces roughness. The scales and specimens provide a common basis for the engineer, draftsman, machinist, and inspector in determining, supplying, and approving the correct surface finish.

Jet Engine Opposite-Polarity Ignition Coils are shown below being tested with a General Electric crest voltmeter. The crest voltmeter measures either positive or negative crest voltages. Portable—it does not need an external power supply.

DINGS MAGNETIC SEPARATOR COMPANY RECOMMENDS USE OF G-E GAUSS METER

Dings Magnetic Separator Co., Milwaukee, Wis., manufacturer of magnetic separators, recommends the G-E gauss meter for determining the strength of the horseshoe magnets used in their separators. Reports Mr. Karl A. Blind, Chief Engineer at Dings, "We are recommending the G-E gauss meter to operating personnel in plants where magnetic separators are an essential part of production machinery. We believe operators should acquire and use the gauss meter for purposes of effectively and rapidly checking the full operating efficiency of the magnet."

Magnetic separators consist of either one or a series of permanent or electromagnets. Materials which contain magnetic foreign particles are passed in a steady flow near the magnets—which remove these foreign particles. This process sometimes requires much repetition, with the strength of the magnets varied each time. In order to do this, the exact strength of each magnet has to be controlled to within narrow limits. The General Electric gauss meter enables operators to maintain these limits.

Designed for unidirectional fluxes, the gauss meter can be used for checking flux densities and flux gradients in air gaps, and for measuring flux density in iron structures.

Ten Photoelectric Recorders Used at Battelle Institute

Battelle Institute, Columbus, Ohio, is now using ten General Electric photoelectric recorders in its industrial-research laboratory.

Some of the recent applications for which photoelectric recorders have been used at Battelle are: differential thermal analysis, and recording short-time high-temperature creep qualities of various metallic and plastic substances. It is also used as a sensitive recording instrument for use in measurement and non-destructive testing where it responds to and signals from devices such as: ionization gages, photoelectric cells, thermocouples, transducers, and strain gages.

The Type CE photoelectric recorder measures d-c volts or amperes directly, and will record almost any quantity that can produce a d-c signal which varies in proportion to the quantity being measured. Chart speeds range from ½ inch per hour to 72 inches per minute; sensitivities are as high as 1.0 microampere full scale; response periods as fast as 1/5 second for full-scale deflection.

SECTION D 602-213, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.
Please send me the following bulletins:
Indicate:
√ for reference only
X for planning an immediate project

- ☐ Gauss Meter (GEC-238A)
- ☐ Surface Specimens & Roughness Scales (GEC-774)
- ☐ Type CE Photoelectric Recorder (GEC-254)
- ☐ Crest Voltmeter (GEC-380)

NAME .....
COMPANY .....
STREET .....
CITY ..... ZONE ..... STATE .....

GENERAL ELECTRIC

5 REASONS WHY

BRONZE DISTRIBUTION CONNECTORS
Give You Better Service
Under Any Operating Conditions

1—NO POWER OUTAGES FROM SEASONAL CRACKING OR STRESS CORROSION CONNECTOR FAILURES.*

2—WILL NOT LOOSEN FROM CONDUCTOR VIBRATION, EXPANSION OR CONTRACTION CAUSING CONDUCTOR DAMAGE OR BURNDOWN.

3—GREATER CONTACT PRESSURES SEAL OUT HIGH RESISTANCE OXIDE FORMATIONS ON CONTACT AREAS AND EQUALIZE CURRENT DISTRIBUTION IN CONDUCTOR STRANDS.

4—EACH COMPONENT MADE OF THE RIGHT ALLOY FOR A SPECIFIC ELECTRICAL OR MECHANICAL FUNCTION. CLAMPING MEMBERS ARE HIGH STRENGTH BRONZE.

5—BACKED BY MANY YEARS OF COORDINATED ELECTRICAL, MECHANICAL AND METALLURGICAL ENGINEERING KNOWLEDGE AND EXPERIENCE IN THE DESIGN AND MANUFACTURE OF PRODUCTS FOR THE ELECTRICAL INDUSTRY.

*TYPES K-90, K-900 AND K, KR ARE DESIGNED TO WITHSTAND MERCUROUS NITRATE TEST ABW SPECIFICATION 124-1 FOR PREDETERMINING SEASONAL AND STRESS CORROSION CRACKING FAILURES.

• OUR PRODUCTS ARE QUALITY CONTROLLED FROM INGOT TO FINISHED PRODUCT

Write today for Bulletins K-150 and K-175 on K-90, K-900 and K, KR Distribution Connectors

Consult one of our nearest 18 representatives or contact our main office

ANDERSON BRASS WORKS, INC.
POST OFFICE DRAWER 2151
BIRMINGHAM, 1, ALABAMA

(*Continued from page 18A*)

works; Dorcey F. Hines, manager, utility sales, Major Appliance Department; and Dean M. Warren, manager, midwest sales district, Lamp Department, Kansas City, Mo.

MacGrath Elected Director of Lear. At the annual meeting of the stockholders of Lear, Inc., held at Grand Rapids, Mich., Kenneth MacGrath was elected to the Board of Directors, and William P. Lear, Russell A. Stevenson, John W. Dregge, and Harold R. Boyer were re-elected as Board members. William P. Lear, Chairman of the Board, is also Director of Research and Development.

Borg-Warner Elects Caldwell. W. B. Caldwell has been elected President of the Borg-Warner Corporation's Calumet Steel Division, Chicago Heights, Ill., and the Franklin Steel Division, Franklin, Pa.

Kennametal to Build New Plant. Kennametal, Inc., has announced the purchase of a 20-acre plot near Bedford, Pa., for construction of a new factory building to house their mining tool fabricating division. This division produces Kentanium, a heat-resistant titanium carbide, which is used in elements of airplane gas turbines.

Sierra Electronic Appointment. Leonard V. Bedell has been named general manager of Sierra Electronic Manufacturing Company, and Vice-President of Electronic Engineering Associates, Ltd., application engineering representatives for Sierra products.

Leeds and Northrup Moves Houston Office. The Houston, Tex., office of the Leeds and Northrup Company has been moved to 2480 Times Boulevard, Houston 5, from its former location, 1314 Texas Avenue.

Westinghouse Appointments. The Westinghouse Electric Corporation has announced the following appointments: Frank Eisenberger, Director of Inventory and Cost Accounting, and G. W. John, assistant director of corporate accounting, both of the Accounting Department; Charles M. Harnish, manager, order service, motor and control division; T. C. Finnell, assistant manager, Application Engineering Department, motor and control division; A. L. Shepler, budget administrator, motor and control division; S. C. Palmer, manager. Transportation Sales Department; and J. A. Schoch, consulting engineer, transportation and generator division.

Standard Transformer Names Representative. The Standard Transformer Company has named the Carl A. Froebel Company as their representative for eastern Missouri and southern Illinois.

Allis-Chalmers Promotes Hanley. Thomas J. Hanley, formerly service and

(*Continued on page 30A*)

Conserve Critical Copper and Steel

WITH Hi **ROCKBESTOS A.V.C.**

...Your best buy

YOU USE

37% LESS COPPER—30% LESS STEEL

For a 430 ampere load, 3ø, 3 wire, 40°C Ambient, 100' run—NEC chapter X

		TYPE RH	TYPE A.V.C.	
CONDUIT	SIZE	4 inch	3 inch	A saving of 327 lbs. of steel
	WEIGHT	1089 lbs./100'	762 lbs./100'	
CABLE	SIZE	800 MCM	500 MCM	A saving of 277.8 lbs. of copper
	WEIGHT	741 lbs./100'	463.2 lbs./100'	

Write for booklet "Rx for a Building with Hardening of the Arteries."

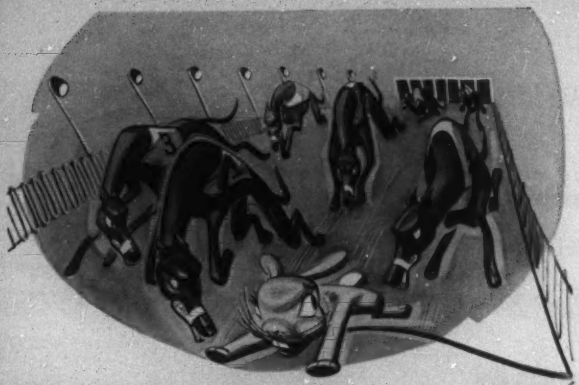
Hi H-E-R

...Your best buy

ROCKBESTOS PRODUCTS CORPORATION

NEW HAVEN 4, CONNECTICUT

Chicago, Detroit, Pittsburgh, St. Louis, Cleveland, New York, New Orleans, Los Angeles, Oakland, Calif.



Saved... By a Dow Corning Silicone

The pelt of many a mechanical rabbit has been saved by rewinding the motors that drive them with Dow Corning Silicone (Class H) electrical insulation. That's a modern Aesop's fable* uncovered by our Atlanta office.

Here's the moral. When your private or corporate life depends upon continuous operation, specify Dow Corning Silicone insulated motors, generators, transformers or solenoids. The more it costs you to permit a motor to fail, the more imperative it is to prolong the life and to increase the reliability of that motor with Class H insulation made with Dow Corning Silicones.

For about twice the cost, you get ten times the life; for a few hundred dollars, you save several thousand dollars in lost production, man hours of labor, maintenance costs and repair bills.

Write today for more information on how you can keep ahead of the pack with Dow Corning Silicone (Class H) Insulation.

* **This fable can be and has been acted upon to save the less expendable hides of some of the most able electrical maintenance engineers.**

MAIL THIS COUPON TODAY

DOW CORNING CORPORATION, MIDLAND, MICHIGAN
Please send me more information including list of Class H motor shops and Class H motor manufacturers. H-8

Name_____ Title_____
Company_____
Street_____
City_____ Zone____ State_____

DOW CORNING CORPORATION
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WASHINGTON, D. C. • In CANADA: Fiberglas Canada Ltd., Toronto • In GREAT BRITAIN: Midland Silicones Ltd., London.

Application Guide
for
GROUNDING of INSTRUMENT TRANSFORMER SECONDARY CIRCUITS and CASES

The object of this guide, number 52, (based on the findings and conclusions of the AIEE Relay Committee) is to give recommendations as to whether all instrument and auxiliary transformers, irrespective of voltage, should be grounded, or just how this grounding should be done.

These recommendations apply to all instrument transformers, irrespective of the value of primary voltage or whether the primary windings of the transformers are connected to or in power circuits, or whether these primary windings are connected in the secondary circuits of other instrument transformers.

There is no charge for copies.

Order Department

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York 18, N. Y.

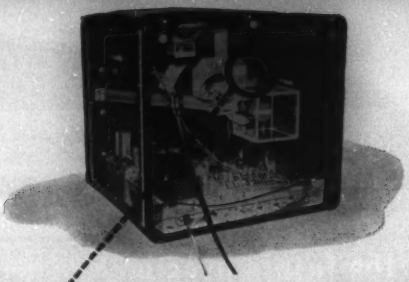
8-51

ELECTRIC POWER DISTRIBUTION FOR INDUSTRIAL PLANTS

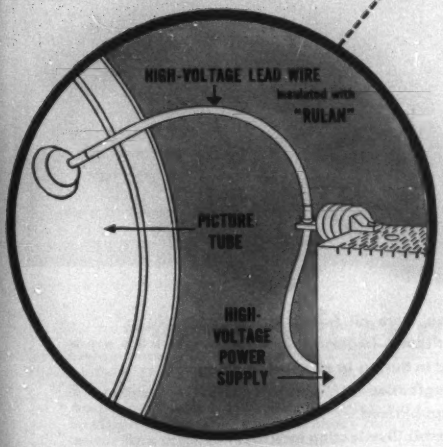
This report, S-3, outlines engineering principles in the design of electric power distribution systems for industrial plants and in the selection of equipment for these systems, from the point of entry of the power company service or the plant generating bus to the terminals of the utilization devices. Price $1.00—no discounts allowed. Address:

AIEE ORDER DEPARTMENT
33 West 39th Street
New York 18, N. Y.

8-51



Dielectric strength of Du Pont "Rulan"



Sketch shows high-voltage wire insulated with "Rulan" connected to kinescope in RCA Victor receiver. Extruded insulation of "Rulan" is only 45 mils thick for 10 kv, 67 mils for 20 kv, and 93 mils for 40 kv.

Wire manufactured by Anaconda Wire & Cable Company, New York, N. Y.

permits smaller cable in RCA Victor TV receiver; flame-resistance increases safety

This high-voltage DC lead wire insulated with Du Pont "Rulan"* flame-retardant plastic is a space-saver in RCA Victor television receivers. The high dielectric strength of "Rulan" permits a thinner insulating jacket for the cable. The jacket on a 10,000-volt lead is thin as a soda straw!

The insulation efficiency of "Rulan" is shown by its high resistance to corona in these TV leads. The dielectric constant is 2.7 and the power factor is 0.002—both constant over a wide range of frequencies. "Rulan" is non-tracking. And—important for safety—"Rulan" is flame-resistant and will not support combustion.

You'll be seeing more and more of this tough, flexible insulating plastic. "Rulan" can be used with no sacrifice of efficiency at temperatures as low as -76° F. and has very low water-absorption (only 0.02% by A.S.T.M. test). Excellent for neon sign cable, high-voltage hook-up wire, multi-conductor cable, signal control wire, high-voltage street-lighting cable, and many other applications where a flame-resistant insulation is needed.

Because "Rulan" contains no plasticizer, it is useful in non-migrating jackets. It can be extruded onto wire at high speeds and can be injection-molded.

Demand for Du Pont "Rulan" currently exceeds supply. However, we suggest you investigate the versatile properties of "Rulan" for future application. For more information write:

*TRADE-MARK

E. I. du Pont de Nemours & Co. (Inc.),
Polychemicals Dept., District Offices:
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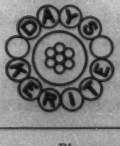
. . . THROUGH CHEMISTRY
Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS

The miracles of modern electric illumination were all foreshadowed by the glow of Edison's first lamp—implicit in the great IDEA. Also implied in this, as in all epoch-making inventions, were the corollary imagination and effort of thousands of unpublicized successors—pioneers of America's vital electric illuminating industry.

KERITE insulation was well established before the turn of the century. Already famous in telegraphic and signal applications, Kerite quickly won recognition for safety, dependability, and ultimate economy in the infant lighting and power industry . . . for the transmission of electric power via aerial, underground, and submarine cable.

By conscientious workmanship, careful handling, and a continuing search for new and better applications of its unique formula, The Kerite Company has been able to anticipate the power industry's needs. It will continue to apply itself to the technical world of "ideas" in which now, as in Edison's day, the future of America's power still lives.



KERITE CABLE

Kerite Insulation—Your Cable's Best Life Insurance

Brush recorder

...memory for an electronic brain

● Goodyear Aircraft's Electronic Differential Analyzer provides a method of studying performance of dynamic systems without computations by a corps of mathematicians.

Since there is a direct analogy between the dynamic behavior of electrical and mechanical systems, the performance of one system can be predicted by a study of the other. Thus, by setting up the proper electrical circuits, problems in such varied fields as aircraft design and control, vibration analysis, industrial control, structures, turbines and engines, and other dynamic systems can be solved with the Differential Analyzer.

The memory for this electronic "brain" is provided by a Brush Recording Analyzer. Here, results from as many as six different computations are recorded simultaneously. Permanent visual records are made instantaneously, eliminating laborious plotting.

Investigate Brush instruments for studies of d-c or a-c voltages or currents, strains, displacements, light intensities, temperatures, and other static or dynamic conditions. Write for information. The Brush Development Company, Dept. L-9, 3405 Perkins Avenue, Cleveland 14, Ohio, U. S. A. *Canadian Representatives:* A. C. Wickman (Canada) Limited, P. O. Box 9, Station N, Toronto 14, Ontario.

Heart of each Brush Recorder is the Brush Magnetic Penmotor—a high-speed, direct-writing element for instantaneous, permanent recording. Flat frequency response and linear phase shift with frequency permit accurate reproduction of both transient phenomena and steady state signals.

Put it in writing with a

BRUSH RECORDING ANALYZER

THE **Brush** DEVELOPMENT COMPANY

PIEZOELECTRIC CRYSTALS AND CERAMICS • MAGNETIC RECORDING • ELECTROACOUSTICS • ULTRASONICS • INDUSTRIAL & RESEARCH INSTRUMENTS

TAC does what no other tool can do!

AT LAST! AN OPEN-END RATCHET WRENCH — the world's first true *universal* wrench. A patented design for connections on tubing, rods, piping, conduit, studs, etc. Sixty-four socket sizes from ¾" to 4". Smallest effective ratcheting arc yet — 5° to 7½°. TAC will also do every job any ordinary ratchet wrench will do: one TAC set replaces literally dozens of single-purpose hand tools.

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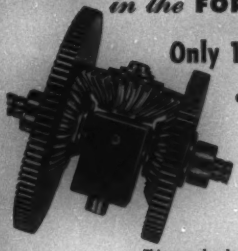
NEW *precision* **DIFFERENTIAL**

in the **FORD** *tradition*

Only 1 Spider Gear



available in:

- 3/16-inch
- 1/4-inch
- 5/16-inch

shaft diameters

This new development, Ford's latest in precision computing mechanisms, incorporating Zerol gears, makes for higher accuracy, far less friction, with a resultant greater life expectancy— a differential of fine Ford precision.

FORD

- **LOW FRICTION:** This smooth-running differential is unique—its exceptionally low friction is the same in either direction.
- **HIGH ACCURACY:** Lost motion does not exceed 5 minutes of arc on the 1/4-inch and 5/16-inch differentials and 7 minutes on the 3/16-inch differential.

FORD INSTRUMENT COMPANY

Division of The Sperry Corporation
31-10 Thomson Avenue
Long Island City 1, N.Y.

Cut Testing Time of Ignition Coils

TESTING JET-ENGINE opposite-polarity ignition coils with a crest voltmeter.

CREST VOLTMETER

For design or production testing, the G-E crest voltmeter is easy to use. Even without special training, you can easily take accurate readings that usually require more cumbersome methods.

SELF-CONTAINED BATTERY, plus light weight and special carrying handle make it portable. This portability saves time when field testing is necessary.

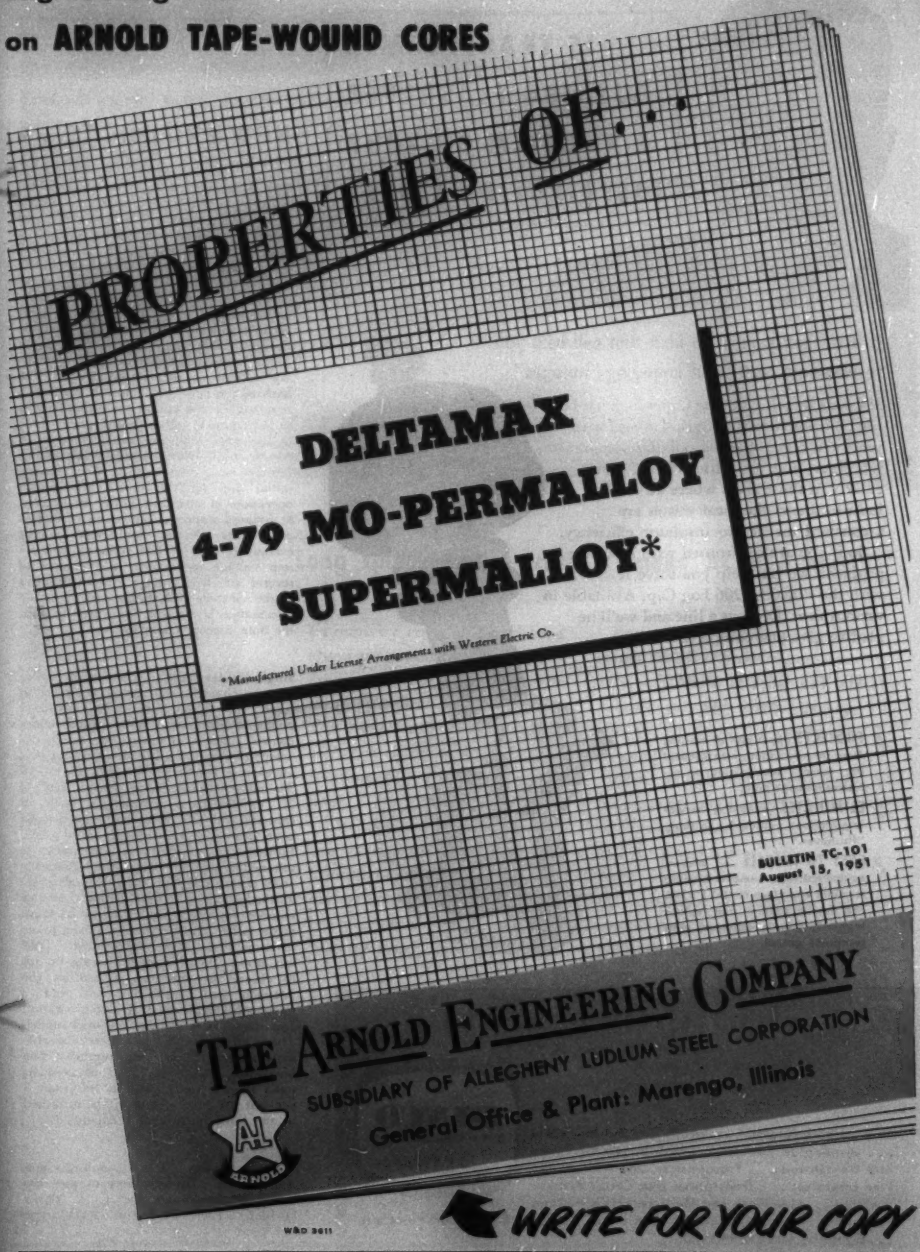
UP TO 30,000-VOLT CRESTS can be measured with this instrument. The crest voltmeter will measure either positive or negative voltages. For complete information and prices, contact your local G-E representative or write General Electric Company, Schenectady 5, New York.

GENERAL ELECTRIC

660-214

Engineering Data

on ARNOLD TAPE-WOUND CORES



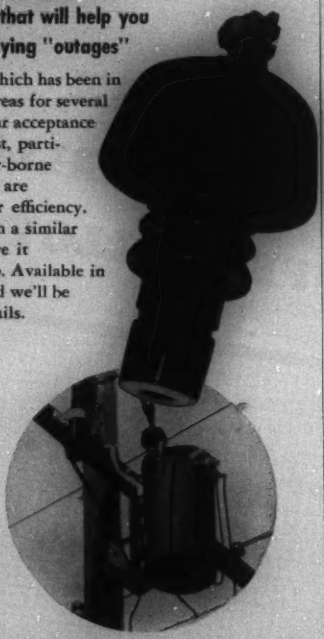
WRITE FOR YOUR COPY

IS TRANSFORMER BUSHING FLASHOVER A PROBLEM ON YOUR DISTRIBUTION LINES?

If it is, then here is an idea that will help you to eliminate costly and annoying "outages"

It's the Pinco L 5206 Fog Cap which has been in use on installations in coastal areas for several years and is now finding popular acceptance wherever "fog" conditions exist, particularly in those areas where air-borne industrial and chemical wastes are a constant menace to insulator efficiency.

So if you are confronted with a similar problem, we can help you solve it with the Pinco L 5206 Fog Cap. Available in various sizes. Drop us a line and we'll be glad to give you complete details.



FEATURES OF THE PINCO L 5206 FOG CAP

1 **PROTECTS** upper part of bushing from contamination; also keeps it dry, thereby maintaining an effective leakage path.

2 **ELIMINATES** annoying service interruptions caused by bushing "flashover."

3 **EASY TO INSTALL** on present equipment. Just remove bushing terminal and place PINCO L 5206 Fog Cap in position and replace terminal. Cap is equipped with coreprene gasket.

The Porcelain Insulator Corporation

Sales Agents: JOSLYN MFG. & SUPPLY CO.
Offices in Principal Cities

PINCO INSULATORS

(*Continued from page 22A*)

erection engineer, has been promoted to supervisor of electrical and hydraulic turbine service and erection for the Allis-Chalmers Manufacturing Company.

NEW PRODUCTS • •

The Sensivolt. A new device expected to solve hundreds of electrical control problems in industry has been developed by the Sola Electric Company, 4633 West 16th Street, Chicago 50, Ill. The invention, called the Sensivolt, controls electric machinery by reacting to very slight changes (as small as 1/2 volt) in the alternating voltage. It can be employed to react automatically to whatever unpredictable fluctuations occur in line voltage, or it can be stimulated deliberately by modulating voltage at the power source. The basis of the new Sola Sensivolt involves a resonant electric circuit somewhat similar to the coastant voltage transformer. One of the applications of this control is in combination with a power relay and a resistor as a switching device. Among initial uses for the device are remote operation of auxiliary power equipment at isolated stations; protection of motors and other electric equipment against excessively high or low voltage; step-by-step voltage regulation; and control of several selective voltage circuits from a single variable voltage source. Further information is available upon request from the Sola Electric Company.

Single-Spider Gear. A new single-spider gear mechanical differential designed to meet the requirements of advanced analogue computers and special close-control instrumentation has been developed by the Ford Instrument Company, Division of The Sperry Corporation, 31-10 Thomson Avenue, Long Island City 1, N. Y. Positional accuracy is built in through the use of special curved-tooth bevel gears with a zero-degree spiral angle. Further improvement in accuracy is attained by using the largest pitch-diameter gears compatible with the minimum overall dimensions of the differential. In this manner the inherently low linear backlash at the pitch diameter becomes even lower in terms of the shaft displacement. Thus lost motion in the shaft is guaranteed not to exceed five minutes of arc on the 1/4-inch and 5/16-inch models, and 7 minutes of arc on the 3/16-inch model and 7 minutes of arc on the 3/16-inch model. This new differential is interchangeable with older (2-gear) differentials. The breakaway torque is 1/100 ounce-inch; static friction under load is less than 5 per cent. Further details will be furnished by the Ford Instrument Company.

Vacuum System. A new vacuum system designed for a wide variety of uses has been introduced by the RCA Victor Division. The instrument, RCA type

(*Continued on page 40A*)

Photo courtesy Bonneville Power Administration

Long spans, heavy icing . . . make ACSR a must!

Extreme ice conditions and long spans are common in the rugged mountain country crossed by The Bonneville-Grand Coulee System. The *strength* and the *dependability* of ACSR (Aluminum Cable Steel Reinforced) are musts for such lines.

The major portion of this system is constructed with ACSR having strength of 31,200 lbs. And in the regions subject to unusually heavy icing an ACSR stranding with 38,400-lb. strength is used.

Bonneville's excellent service record stands as proof of performance of Alcoa ACSR—and of Alcoa's pioneer work in sag, tension, vibration and conductor fatigue problems.

Even though the rearmament program prevents unrestricted use of aluminum, Alcoa stands ready to help you. Look to Alcoa's 63 years of aluminum experience for assistance in planning for trouble-free power transmission projects.

GET TECHNICAL HELPS—NO OBLIGATION

Write for literature on construction of power lines, data on conductors, sag, tension, vibration and fatigue. Address: ALUMINUM COMPANY OF AMERICA, 2102-H Gulf Bldg., Pittsburgh 19, Pennsylvania.

ALCOA

ALCOA FIRST IN ALUMINUM FIRST IN A·C·S·R

Aluminum Cable Steel Reinforced

Standard

RADIO INTERFERENCE and FIELD INTENSITY Measuring Equipment

Complete Frequency Coverage - 14 kc to 1000 mc!

VLF!

NM - 10A

14kc to 250kc

Commercial Equivalent of AN/URM-6.

Very low frequencies.

HF!

NM - 20A **150kc to 25mc**

Commercial Equivalent of AN/PRM-1. Self-contained batteries. A.C. supply optional. Includes standard broadcast band, radio range, WWV, and communications frequencies.

VHF!

NMA - 5

15mc to 400mc

Commercial Equivalent of TS-587/U.

Frequency range includes FM and TV Bands.

UHF!

375mc to 1000mc **NM - 50A**

Commercial Equivalent of AN/URM-17.

Frequency range includes Citizens Band and UHF color TV Band.

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AIEE REPORTS

These publications are proposals for new standards or test codes, or revisions of present publications, which are in the formative stage.

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16A Electric Control Apparatus for Land Transportation Vehicles (April 1951)

22A Air Switches, Insulator Units, and Bus Supports (October 1949)

24 Protector Tubes (July 1940)

28A Valve and Expulsion Type Lightning Arresters (February 1950)

50 Automatic Circuit Reclosers for A-C Distribution Systems (September 1949)

51 Guiding Principles for Dielectric Tests (September 1949)

52 Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases. (March 1951)

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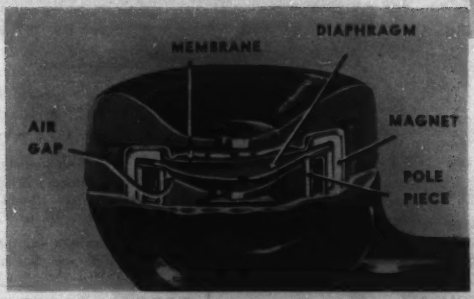
8-51

Easy on the ear



More naturally than ever, your voice comes to the ear that listens through the latest telephone receiver developed at Bell Telephone Laboratories. The reason: a new kind of diaphragm, a stiff but light plastic. Driven from its edge by a magnetic-metal ring, the diaphragm moves like a piston, producing sound over all of its area. Effective as are earlier diaphragms of magnetic-alloy sheet, the new one is better, gives more of the higher tones which add that personal touch to your voice.

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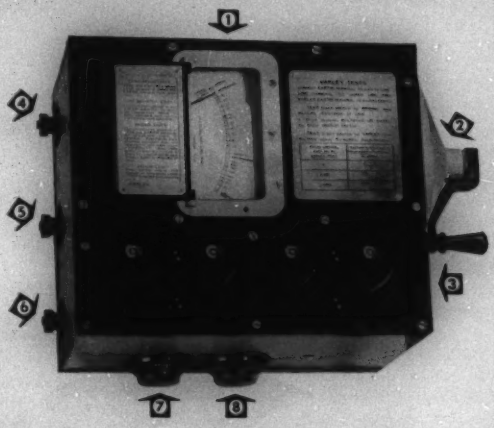
6. This terminal is included in instruments having the Varley Loop feature and is for the Varley Earth connection when locating faults.



7. Change-Over Switch—a multi-position rotary switch for changing internal connections between insulation resistance tests, Wheatstone Bridge measurements and the Varley Loop connection.

8. Ratio Switch—indicates whether the Wheatstone Bridge resistance dial readings should be: ÷100, ÷10, × 1, × 10, or × 100.

For more complete information we will mail you Bulletin 21-60-EE.

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Biddle Ground Tester measures low resistance

Photo Courtesy Copperweld Co.

In spite of apparently good lightning rod or arrester protection, lightning frequently will cause severe damage if high ground resistance hampers its dissipation in the earth. The season for lightning storms is returning to the northeastern states. Now is the time for plants in this section to make a thorough round of ground resistance tests. Aside from the hazards to personnel, thousands of dollars may be saved in damage to electrical equipment and in loss of power and stoppage of production.

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Men concerned with all-around-the-plant electrical tests and resistance measurements tell us that these are "indispensable" tools:

Midget Megger® Insulation Tester for detecting dirt, moisture and deterioration in advance of failure, or as a trouble-shooter after failures occur.

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Rated at 220 kv, 50,000 kva, this huge single-phase unit is one of the largest transformers built by Allis-Chalmers. According to its manufacturer . . . "All modern A-C features are incorporated in this equipment, including rigidly braced, vacuum dried and treated coils - controlled gasket compression - fin type radiators - oil sealed inert gas oil preservation, pioneered by Allis-Chalmers and now standard on over 5,000,000 kva of power transformers. In addition to other factors contributing to the reliability of this apparatus are . . ."

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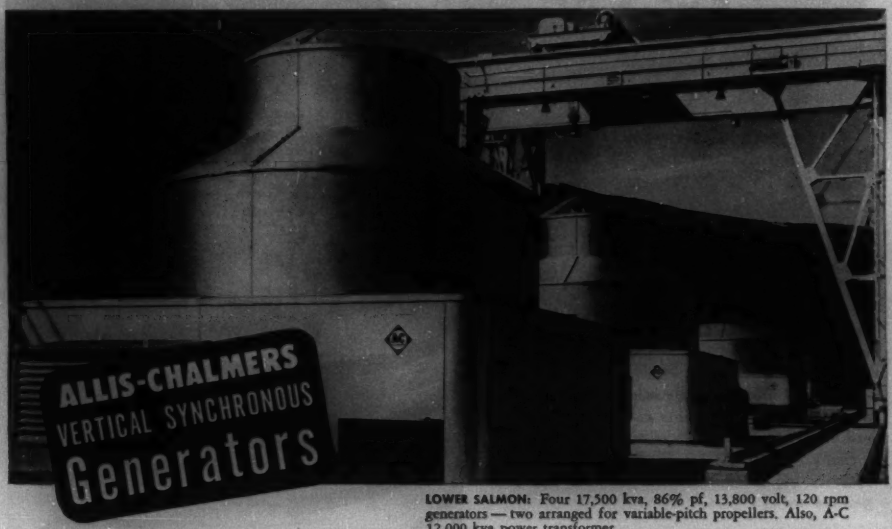
All generators are modified umbrella type (with upper guide bearings) furnished complete with outdoor housings.



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THAT'S the verdict of Mr. Lester Garlinghouse, plant superintendent of Idaho Power's new Lower Salmon, Upper Malad and Lower Malad stations. It's natural that the six Allis-Chalmers hydraulic-turbine-driven generators in these stations should be highly satisfactory: They are the result of more than 40 years' experience designing and building large generators.

Placed in operation in 1948 and 1949, these generators supply southern Idaho as part of the Northwest power pool. The Malad stations, which are remote-controlled from the Lower Salmon station, operate 24 hours a day, seven days a week. Lower Salmon is used for load factoring (peak load operation) and runs at full load an average of about 10 hours a day every day of the year.

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Of course the infrared ray heaters demanded a dependable pathway for power and that they got in TIREX Cables. This picture shows TIREX Cables connected to the heaters. TIREX not only operates dependably day in and day out but it safely combats the sharp abrasive foundry sand, it eliminates the danger from cable fires caused by flying molten metal sparks, and it takes in its stride the everyday abuse that is part of the job.

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Prepared by the AIEE Lightning and Insulator Subcommittee, this bibliography, S-37, contains 754 separate references on lightning and related topics published from January 1, 1936, to December 31, 1949, in most of the better known English, French, and German journals on electrical engineering or physics.

For easy reference, there is a Subject Section, subdivided into 18 classifications, and an Author Section, which contains a list of about 550 authors. Price: $0.70 ($0.35 to AIEE members).

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A series of four articles, compilations of papers originally presented at a symposium on electrical properties of semiconductors and the transistor, held during the AIEE Summer General Meeting, Swampscott, Mass., June 1949. Sponsored by the Subcommittee on Electrical Properties of Solids and Liquids of the AIEE Committee on Basic Sciences.

It is hoped that this pamphlet (S-36, January 1950) will prove useful not only to the practicing engineer and teacher, but also to engineering students as an introduction to this field of electrical engineering.

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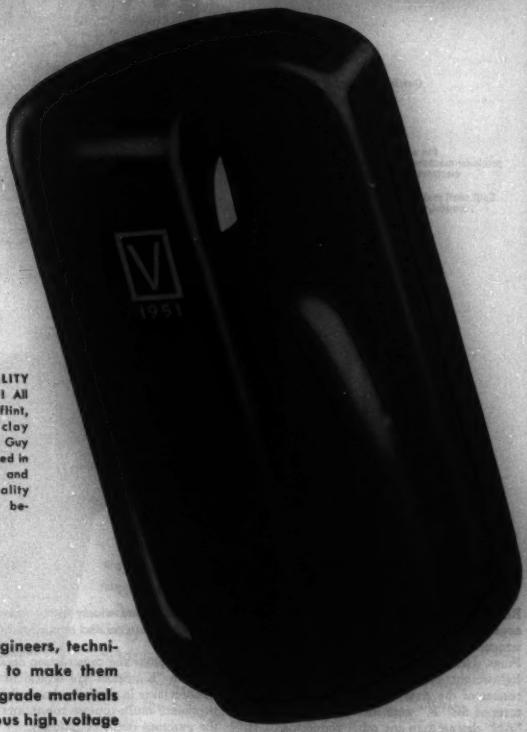

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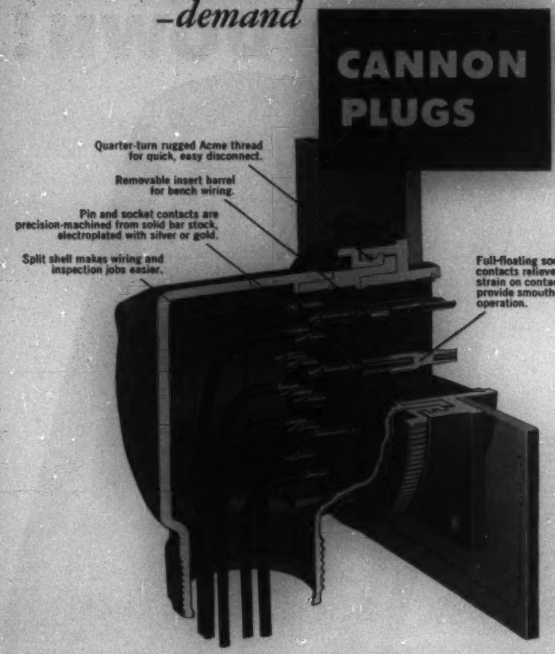
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Recognition of Cannon's 36 years of sound engineering and fine, uncompromising construction has built the demand for Cannon Plugs. Here we take an inside look at the lightweight Type "K" 90° connector, forerunner of the Army-Navy Series. More features of the "K" were incorporated into the "AN" design than any other connector.

Constantly improved over the years, Type "K" is now used for numerous applications such as aircraft, radio, television, sound, phone recorders, motion pictures, geophysical research and widely used throughout the electro-mechanical and electronic instrument fields.

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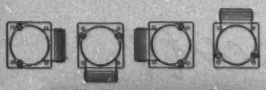

Diagram at left shows how the four positions of cable entry on the large 90° "K" endbell make the wiring job easier. Smaller Type "K" connectors have three positions.

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Factories in Los Angeles, Toronto, New Haven. Representatives in principal cities.

Type "K" and "RK" connectors are available in 7 shell types having 8 diameters. Inserts have more than 190 contact arrangements. Some of these have Coax, Twinax or Thermocouple contacts as standard. Integral cable clamps available in all "K" plug types.

(*Continued from page 30A*)

EMV-5, serves such applications as evaporation of metals and salts, sputtering, applying metallic films, vacuum distillation, drying, preparation of specimens for electron microscopy, study of discharges in gases at low pressures, study of phosphors under electron and ion bombardment, and study of electrical and physical properties of materials at low pressures and in various atmospheres. It may also be used for vacuum coating of many items on a production basis. The new *EMV-5* consists essentially of a vacuum chamber (18-inch diameter bell jar, base plate, and nine terminals) and a high-speed pumping unit for evacuation. A mechanical fore pump and an oil diffusion pump serve to evacuate the vacuum chamber to 0.1 micron mercury (1/1,000th of a millimeter of mercury pressure) in less than 7 minutes. A cold-cathode discharge gauge is used to measure the pressure in the chamber. Working range is from 1 millimeter mercury to 10^{-4} millimeter mercury. The system has a power requirement of 2,500 watts at 105 to 125 volts, 60 cycles, and a water consumption of 3 cubic centimeters per second. RCA Victor, division of the Radio Corporation of America, Camden, N. J., will supply any further information.

Automatic Illumination Control. A weatherproof illumination control of the plug-in type has been announced by the Weston Electrical Instrument Corporation, 641 Frelinghuysen Avenue, Newark 5, N. J. Known as the model *1089*, the unit provides completely automatic on-off control of artificial lighting at predetermined light levels. Mounted in a watt-hour meter glass case, the unit consists of a stable dry-disc type photocell, a sensitive relay which is operated directly by the photocell, a clock motor, mercury switch, and limit switch. It contains no phototubes or vacuum tubes, requires no standby power, and has no resistors or capacitors. It will withatand adverse climatic conditions at temperatures as high as 140 degrees Fahrenheit down to −30 degrees Fahrenheit. Descriptive literature can be secured from the manufacturer.

Load-Chek. Designed for radio and television servicing, the Triplett model *660* Load-Chek watt-voltmeter provides a method of auto-radio servicing by power consumption measurements. Double meter indication provides a simultaneous check of line voltage and power; shows faulty power line wiring as well as proper functioning of the appliance under test. Ranges are 0 to 500 to 1,000 watts a-c or d-c, 0 to 130 volts a-c or d-c. Further information may be obtained from The Triplett Electrical Instrument Company, Bluffton, Ohio.

Eventometer. The Walkirt type *M 1731* Eventometer measures events occurring in a desired interval of time. It is de-

(*Continued on page 46A*)

RANGE — is continuously adjustable from a minimum of —0.1 to +1 mv . . . up to a maximum of —2 to +20 mv.

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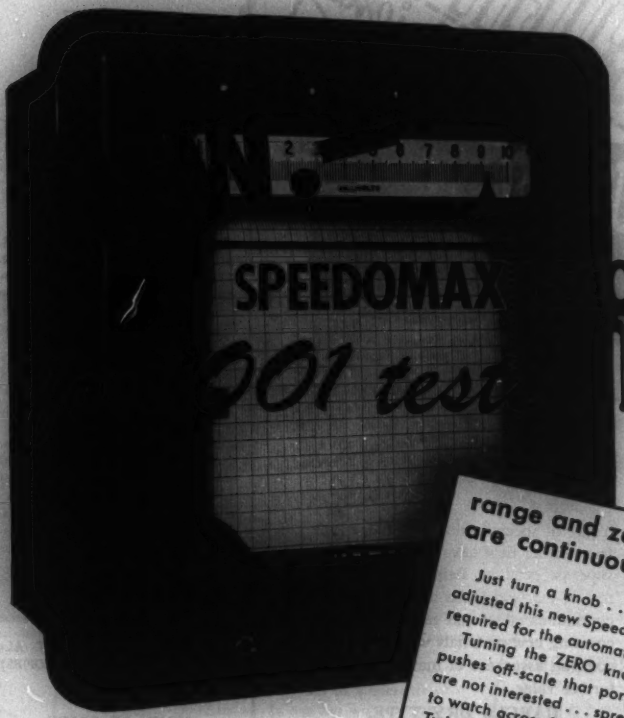

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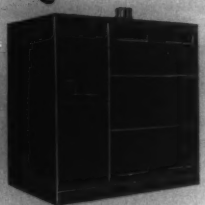

450 KVA, Type F Unit Substation, 4160 V. Delta, 60 Cycles, 3 Ø— 120/208Y, 4 wire.

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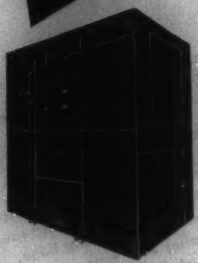

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Do your requirements call for this kind of precision? If you have a special problem, Fairchild Potentiometer Sample Laboratory engineers are always available to help you. For complete data, write, stating your requirements, to *Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Boulevard, Jamaica 1, N. Y. Dept. 140-17L.*

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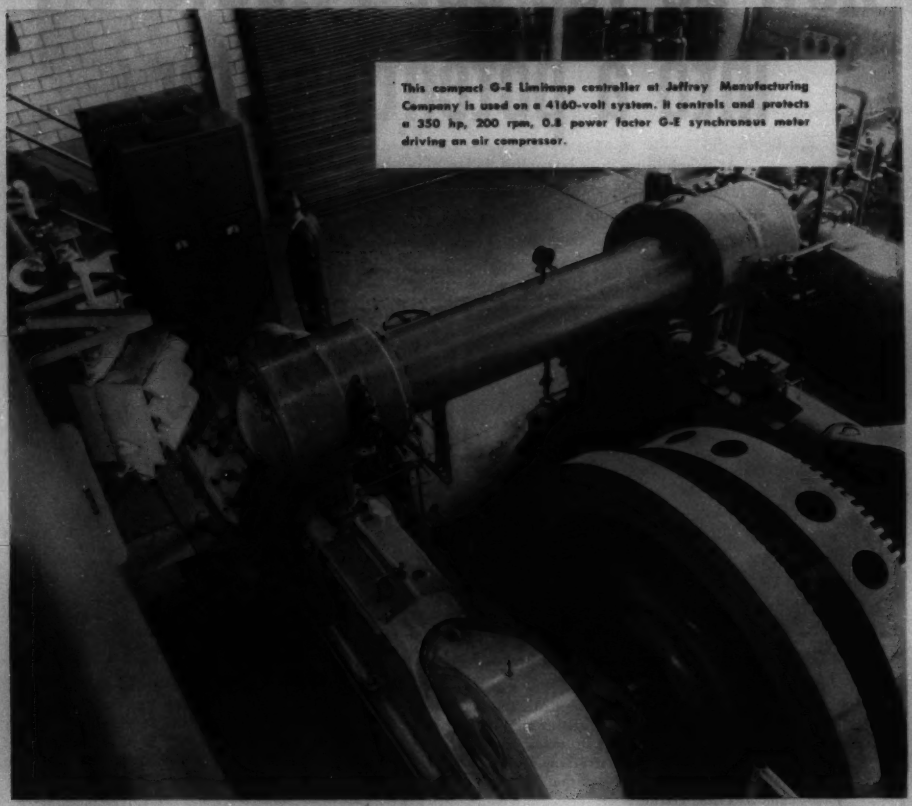
PRECISION POTENTIOMETERS

Jeffrey Manufacturing Uses G-E Limitamp Control



This compact G-E Limitamp controller at Jeffrey Manufacturing Company is used on a 4160-volt system. It controls and protects a 350 hp, 200 rpm, 0.8 power factor G-E synchronous motor driving an air compressor.

This high-voltage control meets a need for ample interrupting capacity, protection for operating personnel, good appearance and compactness

The addition of a large compressor for general plant use called for a synchronous motor and dependable high-interrupting-capacity control at Jeffery's modern power house. In addition to the accurate synchronization obtained with the new field control of this air-break Limitamp controller, and the factors mentioned above, Jeffrey likes the co-ordinated design of this G-E controller that is factory engineered and built. Such a compact, steel-enclosed controller is easily installed, requires little space —yet has all the features that provide protection for both equipment and personnel. And it's quickly inspected and maintained.

Rapid duty cycles do not affect the long life inherent in G-E Limitamp —now available in ratings up to 4800 volts with an interrupting capacity up to 250 mva. Shorts are cleared in less than half a cycle—offering positive protection for your expensive electric equipment. Write for more information on the new Limitamp controller—also available for squirrel cage and wound rotor motor control—in Bulletin GEA-5409. *General Electric Company, Schenectady 5, N. Y.*

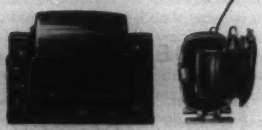
GENERAL ELECTRIC

730-17

Ceroc 200

CERAMIC-COATED MAGNET WIRE

...FOR HIGHER RATINGS IN SMALLER WINDINGS



Same v-a rating! At the left is a filament transformer for a radio transmitter wound with double vinyl-acetyl insulated wire and impregnated with synthetic varnish. It is rated at 1,000 hours life under 85°C. ambient temperature operation. At the right is the same transformer, redesigned, and wound with CEROC 200 and impregnated with silicone resin. It has a rated life of 10,000 hours at 160°C. ambient temperature operation!

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This wire has an exclusive ceramic-silicone insulation which permits continuous operation at 200°C. Size for size, it safely carries far larger currents than ordinary magnet wires using conventional insulating materials. Consequently, CEROC 200 can save both copper and magnetic materials for you.

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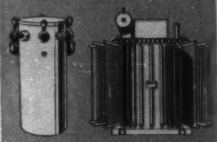
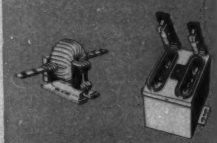
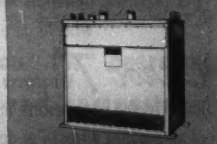


Liquid filled (sizes up to 10,000 KVA and 72 KV inc.)



Instrument transformers (for use on circuits up to 72,000 volts, inc.)



Dry type (up to 1000 KVA and max. voltage ratings of 4800)

Control transformers (compound filled or open type)

(*Continued from page 40A*)

signed to count any signal in the frequency range from 10 cycles per second to 150,000 cycles per second which has an amplitude in excess of 0.05 volt rms but less than 100 volts rms. The instrument contains two counting systems: the first of these, called the time base chain, provides the time base and determines the interval during which the input signal is counted; the second, called the counter chain, counts the unknown input.

The time base chain operates on the binary principle, with feedback, to provide for division by 100,000 from an internal 100-kc oscillator or from an external frequency source. By this division, when using the internal oscillator, a scan time of 1 second is provided resulting in an answer expressed in cycles per second. Through provisions included in the instrument, other frequencies, less than 200 kc, may be used to control the time base so that the scan time may be changed as desired over a range from 1/2 second to an indefinitely long period.

The counter chain is comprised of five decade counters of the binary type using feedback. The input to these counters is passed through a gate, or electronic switch. The period during which the gate is open is the scan time referred to. This counter chain has an upper frequency limit of 150 kc.

Input impedance is 100,000 ohms. The accuracy of the count as indicated is ±1 event, or cycle, for any scan period. Power for the instrument is obtained from two electronically regulated plate supplies, a gas tube regulated bias supply, and a supplemental heater supply transformer. Input voltage required is 105–125 volts, 60 cycles per second. Further specifications may be obtained from The Walkirt Company, 5808 Marilyn Avenue, Culver City, Calif.

TRADE LITERATURE

Bus Ducts. A new 68-page manual, *B-4272A*, describing types of bus ducts and test data, is available from the Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa., upon written request.

Color. "Color Is How You Light It" is the subject of a new book published by Sylvania Electric Products, Inc. The book, number *FL-420*, analyzes the eight colors of white light now available and their effects on 40 colors. Forty large color swatches are used in the color analysis section; other sections include material on light and color, color definitions, color applications, the correlation of source and surrounding color, color psychology, and color in industry. Copies may be secured from the Advertising Department of Sylvania Electric Products, Inc., 87 Union Street, Salem, Mass., at $0.50 per copy.

Valves. A 44-page catalogue describing its complete line of valves is available from the Ross Operating Valve Company, 120 East Golden Gate, Detroit 3, Mich.

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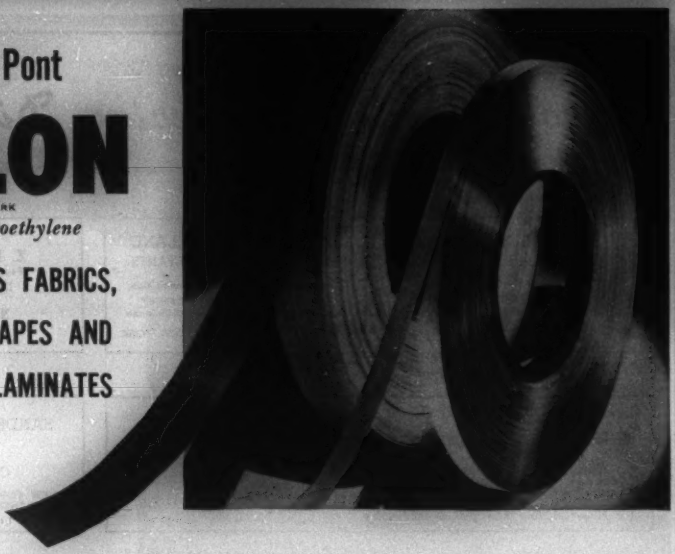

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Dielectric strength, short time, volts/mil.	>500	>500
Surface arc resistance, sec.	>240	>240
Dielectric constant, 60 to 100,000 cycles	2.8	3.0
Power factor, 60 to 100,000 cycles	0.0005	0.0006
Volume resistivity, ohm-cm., room conditions	$5x10^{15}$	$5x10^{15}$
Insulation resistance, ohms (96 hrs. at 90% R.H., 35° C.)	10^{9}	10^{9}

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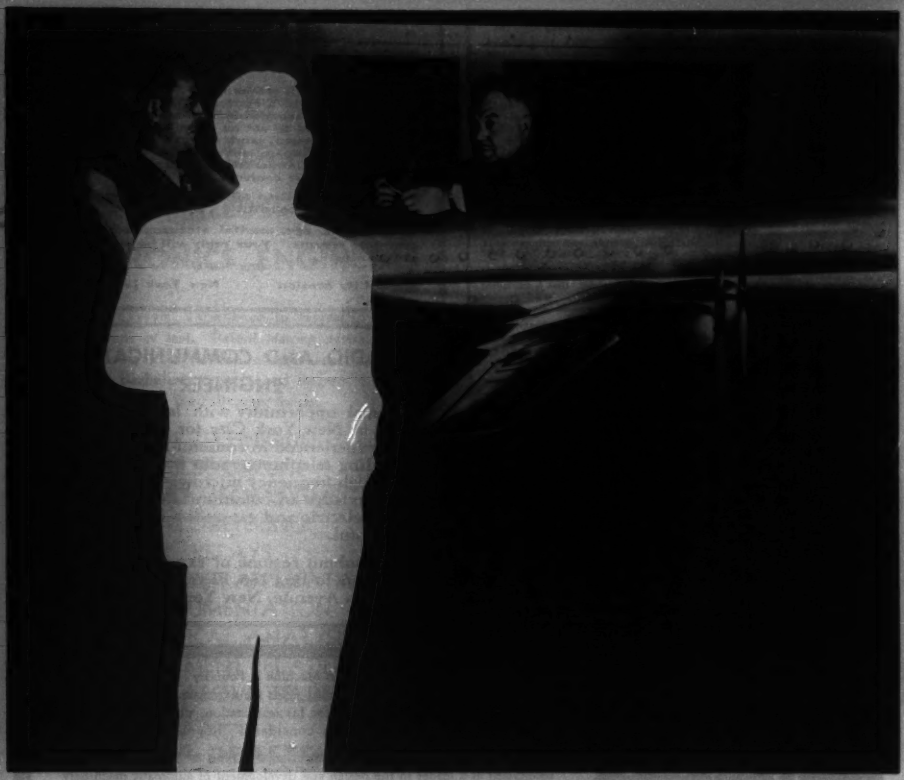

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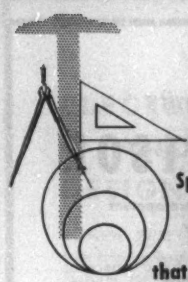

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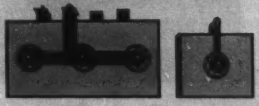

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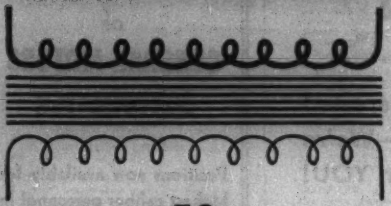

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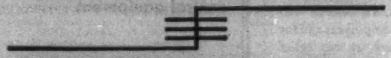

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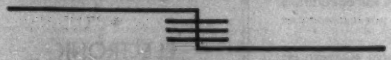

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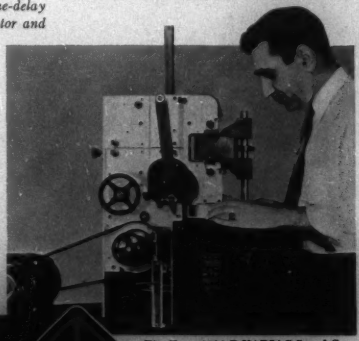

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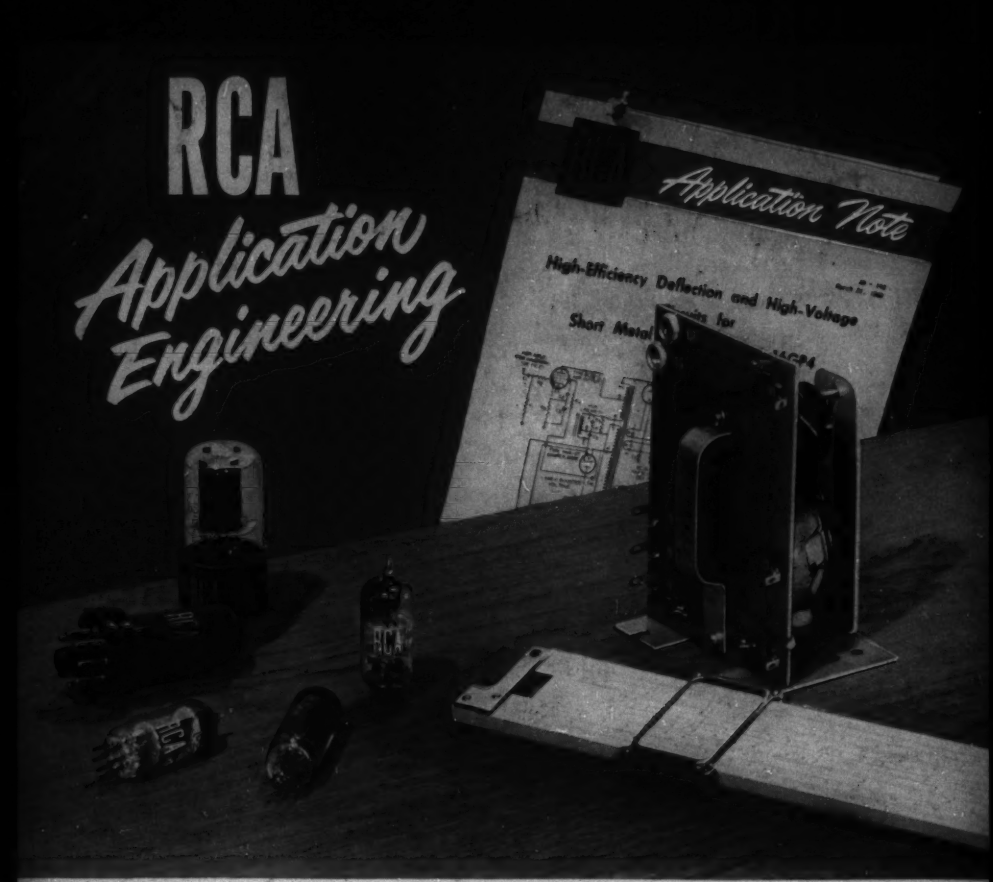

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